

# Global Energy Future after the Fukushima Nuclear Accident

Toshiba Youth Conference for a Sustainable Future

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*Note: The views expressed here are of my own and do not necessarily reflect those of the JAEC nor the government.*

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- Public Policy for Climate Change



# Summary

- Fukushima Dai-ichi nuclear power accident has become one of the worst accidents in nuclear history and **it is not completely over yet. The biggest impact is loss of public trust.** This has serious implications for not only Japan but also global nuclear energy development.
- **Impact of shale gas, improved energy efficiency and expansion of renewables** are the new trends in global energy scenes. Still, challenges for climate change remains.
- **Need all technology options** to meet climate challenge and appropriate policy mix is necessary.
- Global negotiation on climate change is facing difficulties and need **innovative approaches, such as putting carbon price**, are necessary.



# The Fukushima Nuclear Accident



# Personal Reflections on the Fukushima accident

- *Feel deep responsibility and regret for what happened as a person/expert engaged in nuclear energy. Would like to express my sincere apology for all people affected by the accident.*
- Fundamental shift in thinking about risk of nuclear energy.
  - Risk is as large as risks of nuclear proliferation and nuclear security (I thought nuclear safety risk is smaller)
  - Social/political/economic risks are tremendously larger than I thought. It has become an issue of human security.
  - Protection of human lives is not good enough. Release of radioactive materials which would cause long term impacts on society and environment should not be allowed.
  - About 150,000 people are still not living in their own homes and are concerned about their health, future life and future of their homeland. It is heartbreaking to listen to their story, with anger, frustration and anxiety.
- Assuring and restoring life and welfare of people affected by the accident is the top priority.

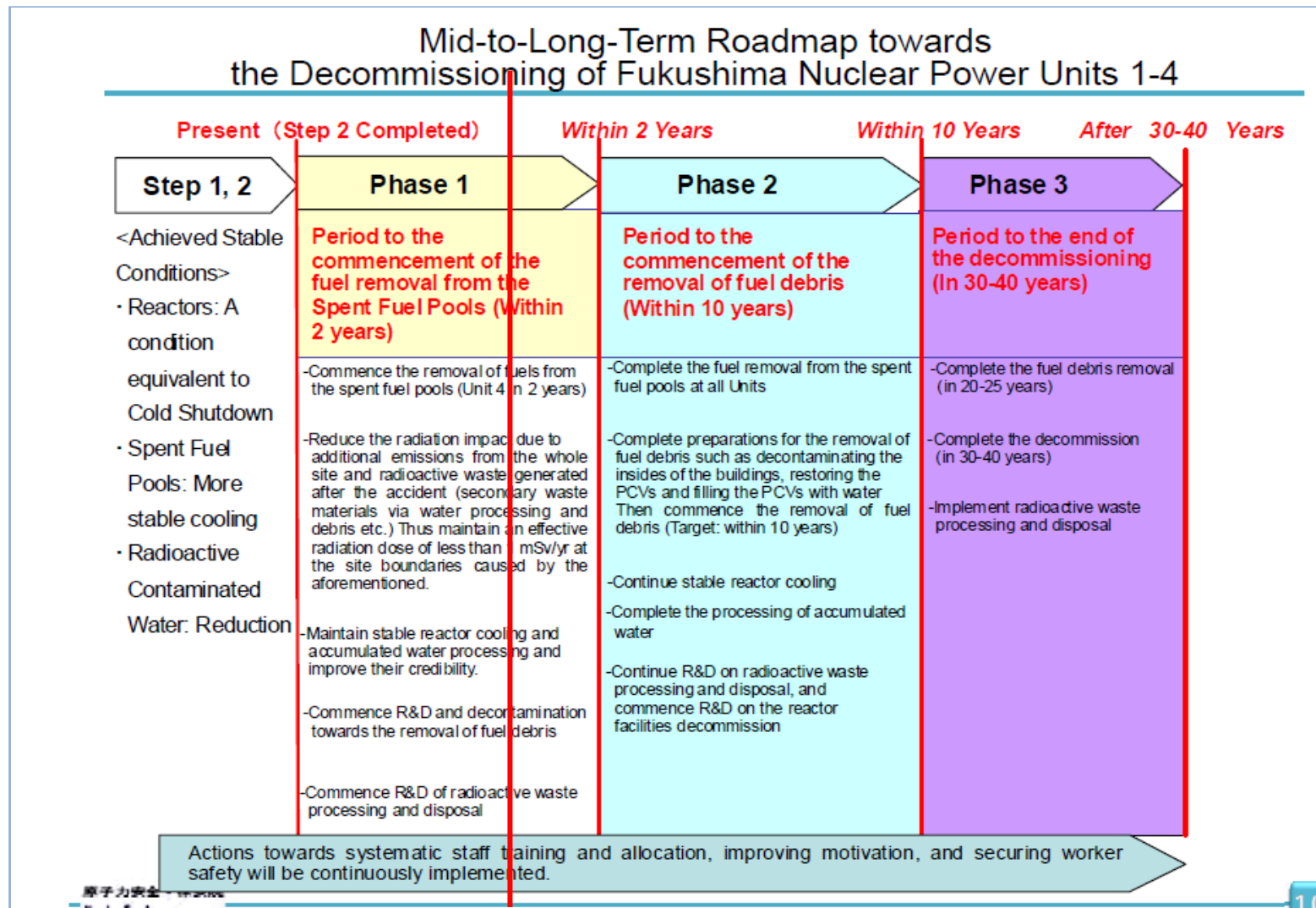


# Current Status

- It will take at least 30 years to clean up and decommission the Fukushima Dai-ichi site.
- Total liability (compensation) amount is estimated to be at least 6 trillion yen (\$60 billion) which is likely to grow further.
- Only two (out of 50) nuclear plants are operating, but due to energy conservation/efficiency improvement efforts no power shortage occurred during this summer peak. Still about 3.5 trillion yen (\$35 billion) was paid more for fossil fuel than last year. All utilities except Hokuriku and Okinawa suffered largest loss (total of 1.3 trillion yen in FY 2012).
- Newly established Nuclear Regulatory Authority (NRA) has been working on new regulatory standards and published its draft. NRA published the standard for reactors in July and plans to publish the standard for nuclear fuel cycle facilities by December. Until its safety is confirmed in accordance of the standards, no reactors/facilities are not allowed to start up.



# Mid-Long Term Roadmap for Fukushima Dai-ichi



2011/12      2013/05

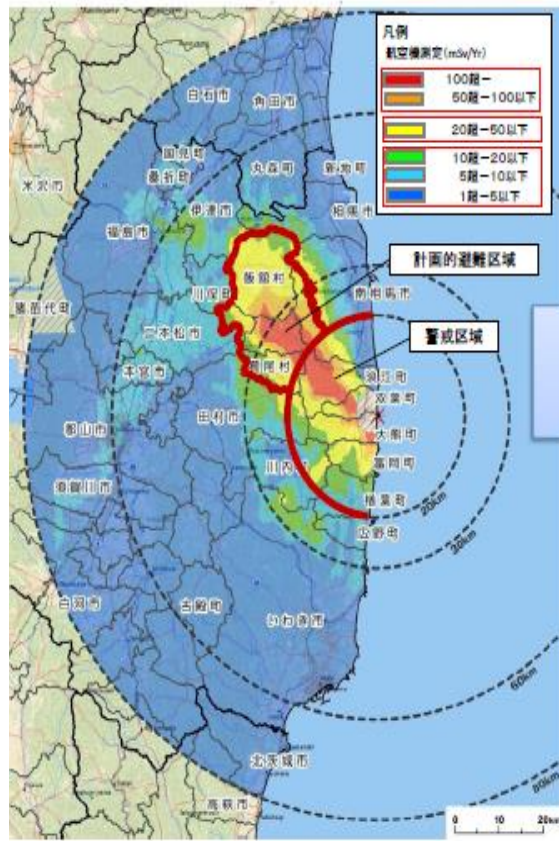
Source: M. Yasui, Nuclear and Industrial Safety Agency (NISA), March 2012,  
<http://www.nsr.go.jp/archive/nisa/english/files/en20120321.pdf>



# Evacuation Area Amended (March 7, 2013)

(As of April 29, 2012)

〔平成23年4月29日時点の  
線量分布〕



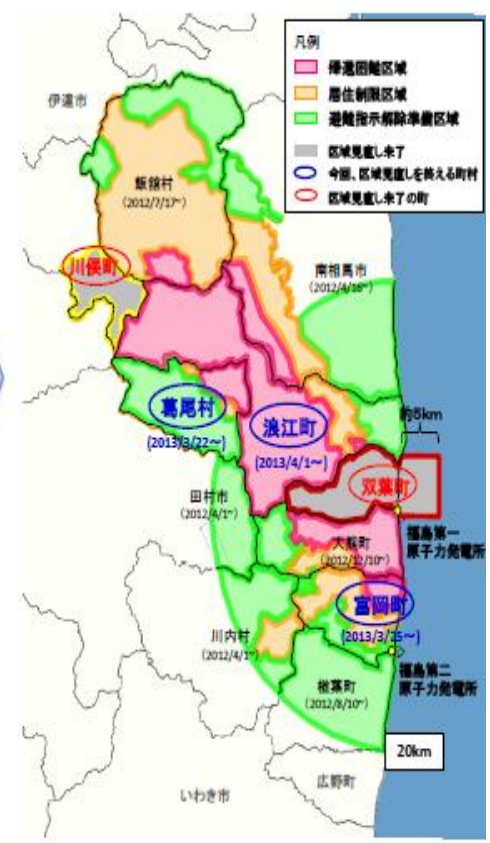
(Dec 10, 2012)

〔平成24年12月10日時点  
(今回の区域見直し前)〕



(After April 1, 2013)

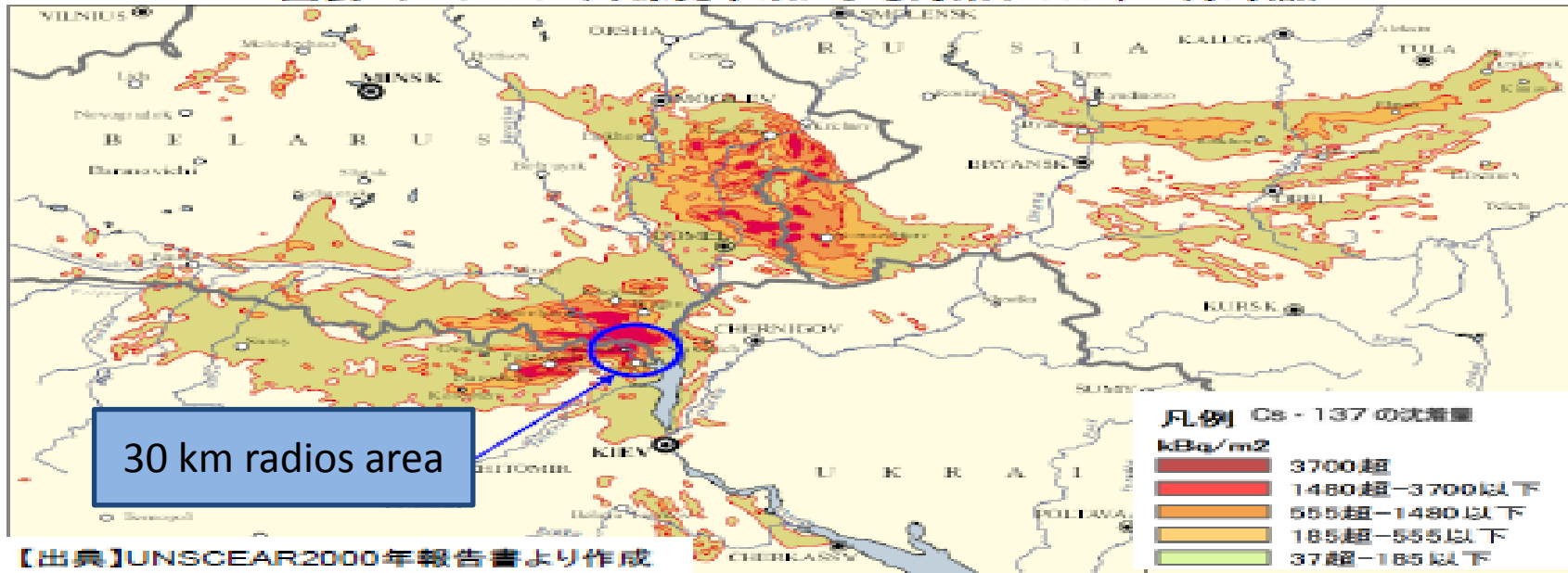
〔平成25年4月1日以降  
(今回の区域見直し後)〕



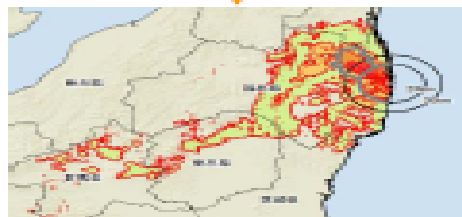


# Compared with the Chernobyl accident

図表 チェルノブイリ原発事故による汚染(1989年12月時点)



両図を同縮尺  
で記載



図表 東電福島第一  
原発事故による汚染  
(2011年11月時点)

【出典】文部科学省発表資料(2011年11月)より作成

図表 汚染地域の面積

汚染濃度 (kBq/m <sup>2</sup> )	汚染地域の面積(km <sup>2</sup> )		
	Chernobyl	Fukushima	F/C
> 1,480	3,100	200	6 %
555 - 1,480	7,200	400	6 %
185 - 555	18,900	1,400	7 %
37 - 185	116,900	6,900	6 %
合計面積	146,100	8,900	6 %

3



# Cherry blossom in Tomioka Town (10 km from Fukushima Daiichi)



[http://img2.blogs.yahoo.co.jp/ybi/1/e6/47/pocoyuko2006/folder/581347/img\\_581347\\_54615521\\_0?1335789300](http://img2.blogs.yahoo.co.jp/ybi/1/e6/47/pocoyuko2006/folder/581347/img_581347_54615521_0?1335789300)



<http://www.asahi.com/special/news/images/TKY201304070098.jpg>

# Most Important Lessons Learned from Fukushima:

## “Thinking Unthinkable” and “Resilience”

- *“The Investigation Committee is convinced of the **need of a paradigm shift** in the basic principles of disaster prevention programs for such a huge system, whose failure may cause enormous damage.”* - from the Interim Report by the Gov’t investigation committee (Dec. 2011)
- “**Thinking unthinkable**” is essential in preparing for the emergency and for energy security.
- “**Resilience**” beyond “defense in depth” is needed for preparing “unexpected crisis”.
  - Resilience means a capability to **respond to “unexpected crisis” as well as to restore safe and secure status** of the social system.

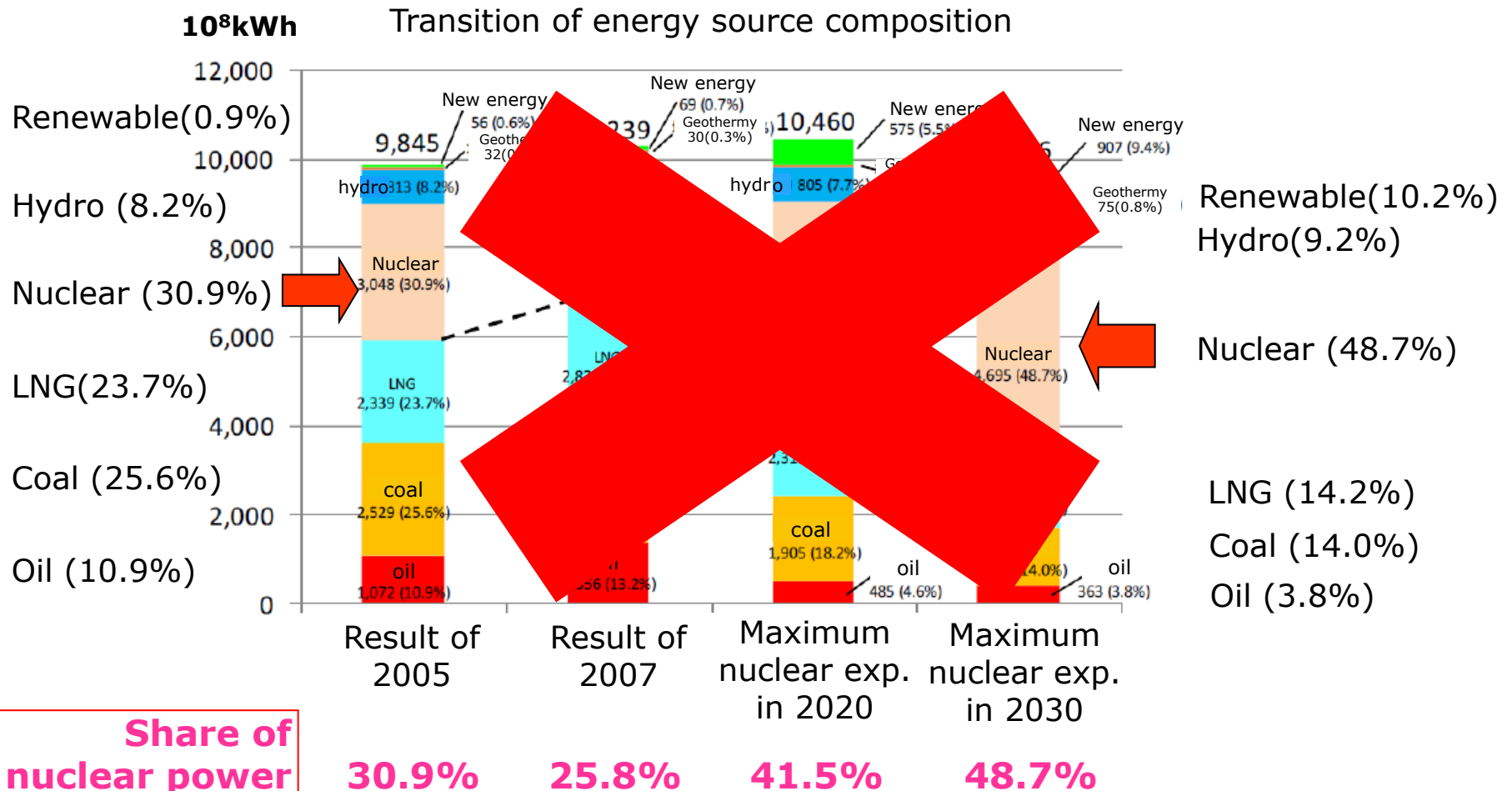


# Japan's energy policy after 3/11



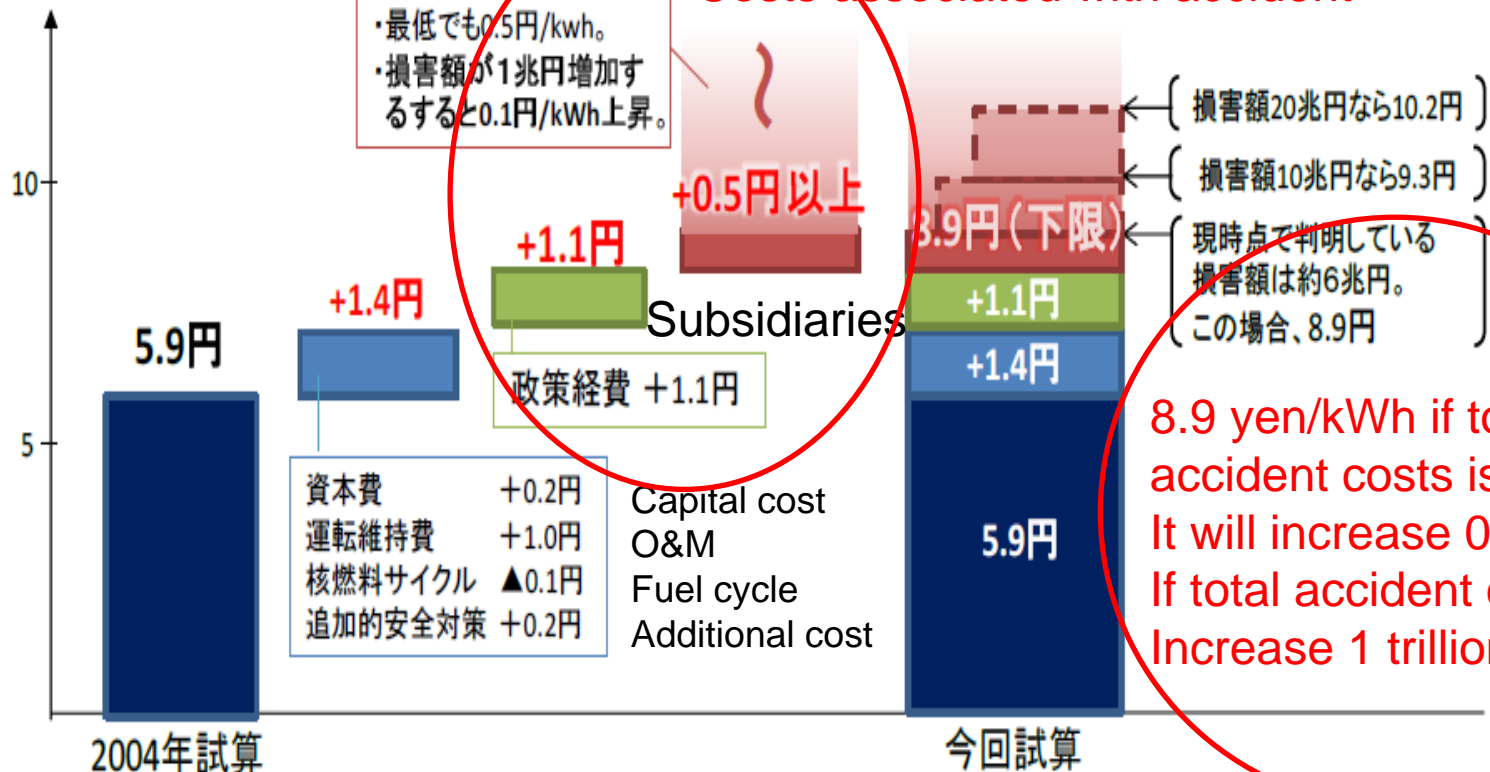
# Goal of Power Production Mix in 2030

## Before 2011/3/11



Source: Institute of Energy Economics, March 2010

Yen/kWh



8.9 yen/kWh if total accident costs is 6 trill yen.  
It will increase 0.1 yen/kWh  
If total accident costs Increase 1 trillion yen.

(図 20) 原子力の発電コスト (2004 年試算と今回試算)

Nuclear Power Generation Costs (2004, 2011)

出所: コスト等検証委員会報告書、2011年12月19日

<http://www.npu.go.jp/policy/policy09/pdf/20111221/siryo3.pdf>

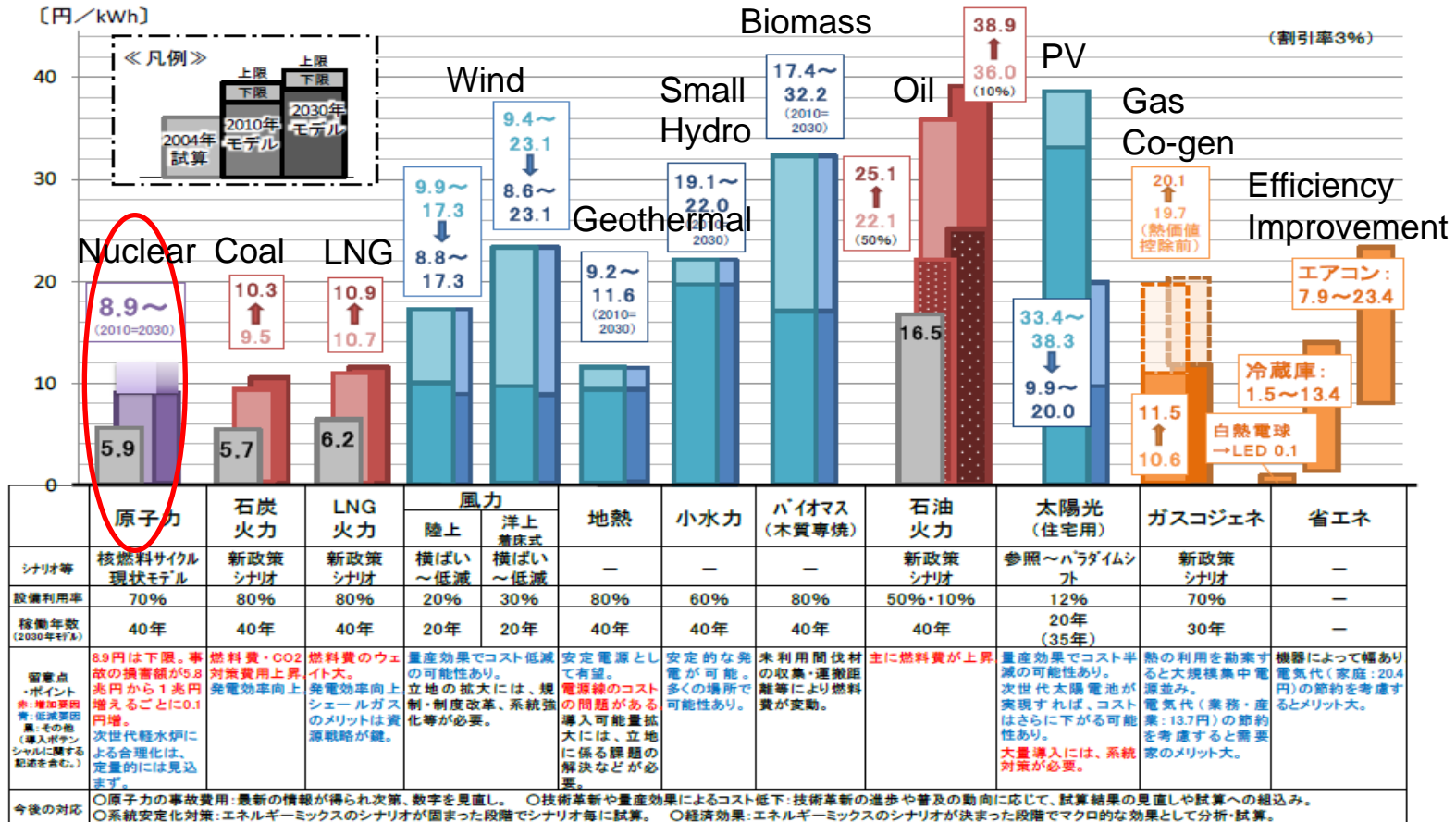




# Nuclear power can be competitive, but social costs can be high...

## 【コスト試算のポイント】

- モデルプラント形式(最近7年間の稼働開始プラント、最近3年間の補助実績等を基に設定)
- CO2対策費用、原子力の事故リスク対応費用、政策経費等の社会的費用も加算。
- 2020年、2030年モデルは燃料費・CO2対策費の上昇、技術革新等による価格低減を見込んで試算。

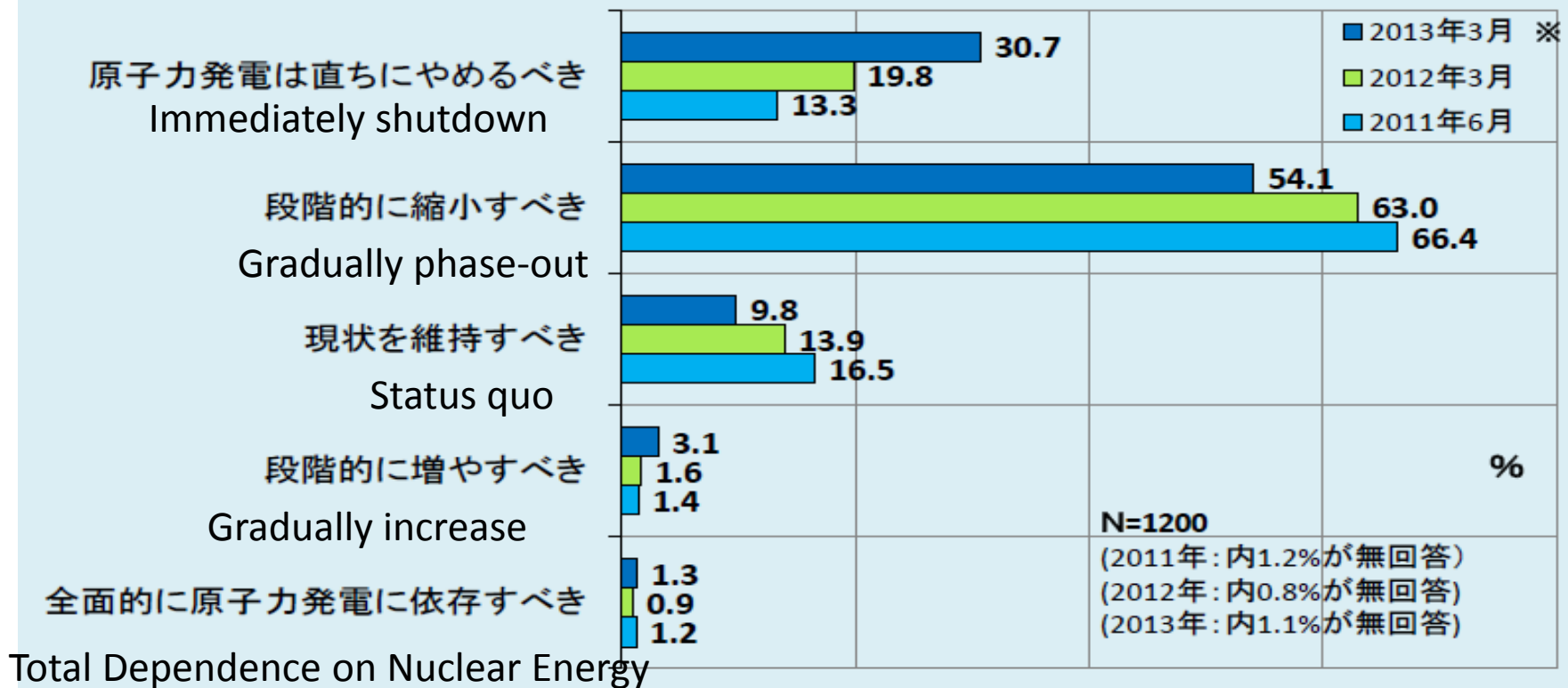


(図 36) 主な電源の発電コスト (2004年試算/2010年・2030年モデルプラント)



出所:コスト等検証委員会報告書、2011年12月19日

<http://www.npi.go.jp/policy/policy09/pdf/20111221/siryo3.pdf>



What is your opinion about nuclear power in Japan?

## 日本の原子力発電はどうあるべきか

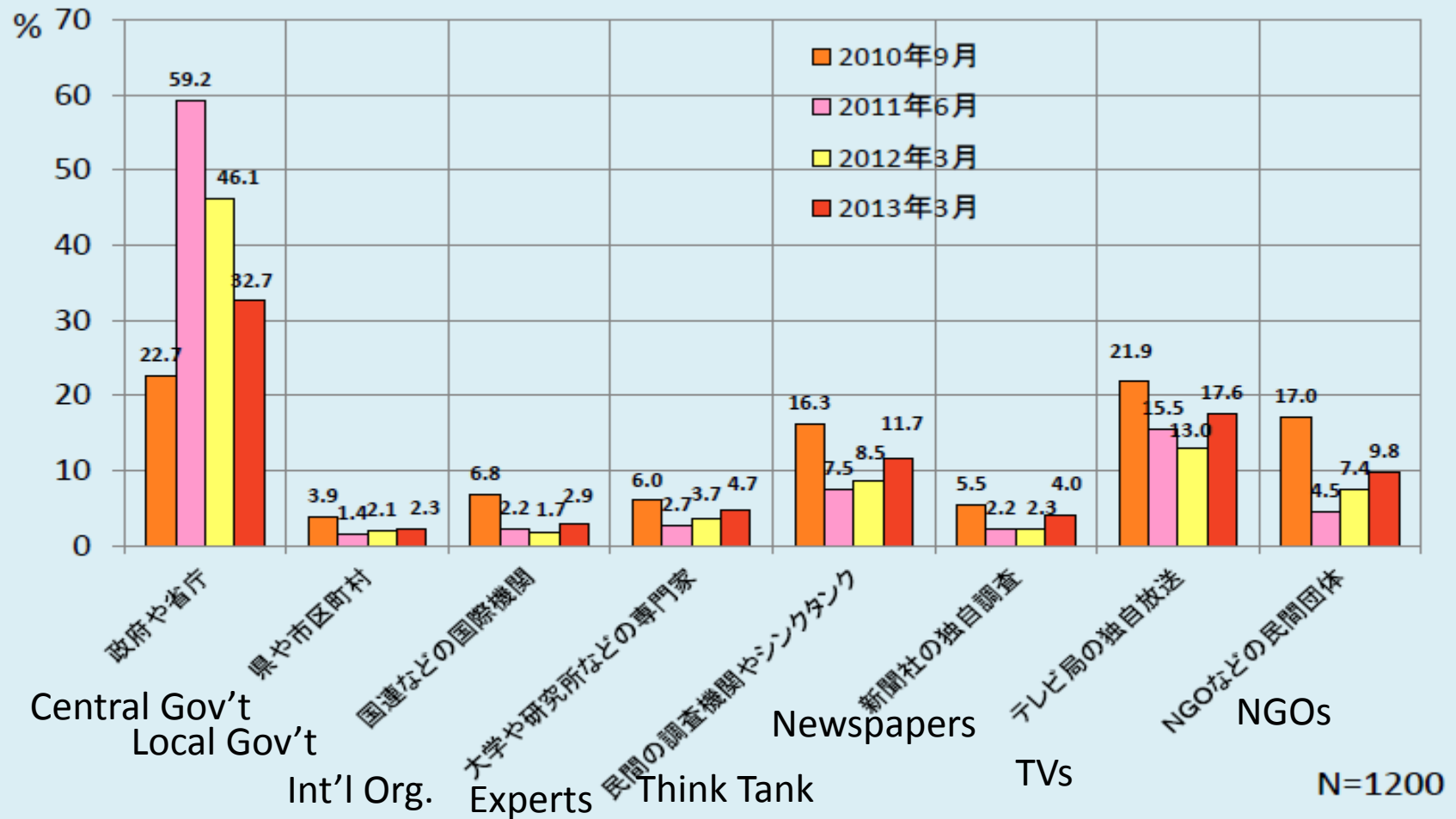
※2013年の調査では、回答項目は「再稼働を認めず、直ちにやめるべき」「再稼働を認めて段階的に縮小すべき」「再稼働を認めて現状を維持すべき」「再稼働を認めて段階的に増やすべき」であった。

Source: Prof. Hirotada Hirose, "Changes of Public Opinion about Nuclear Power,"  
 Presented at Japan Atomic Energy Commission, July 17, 2013

<http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2013/siryo27/siryo2.pdf>



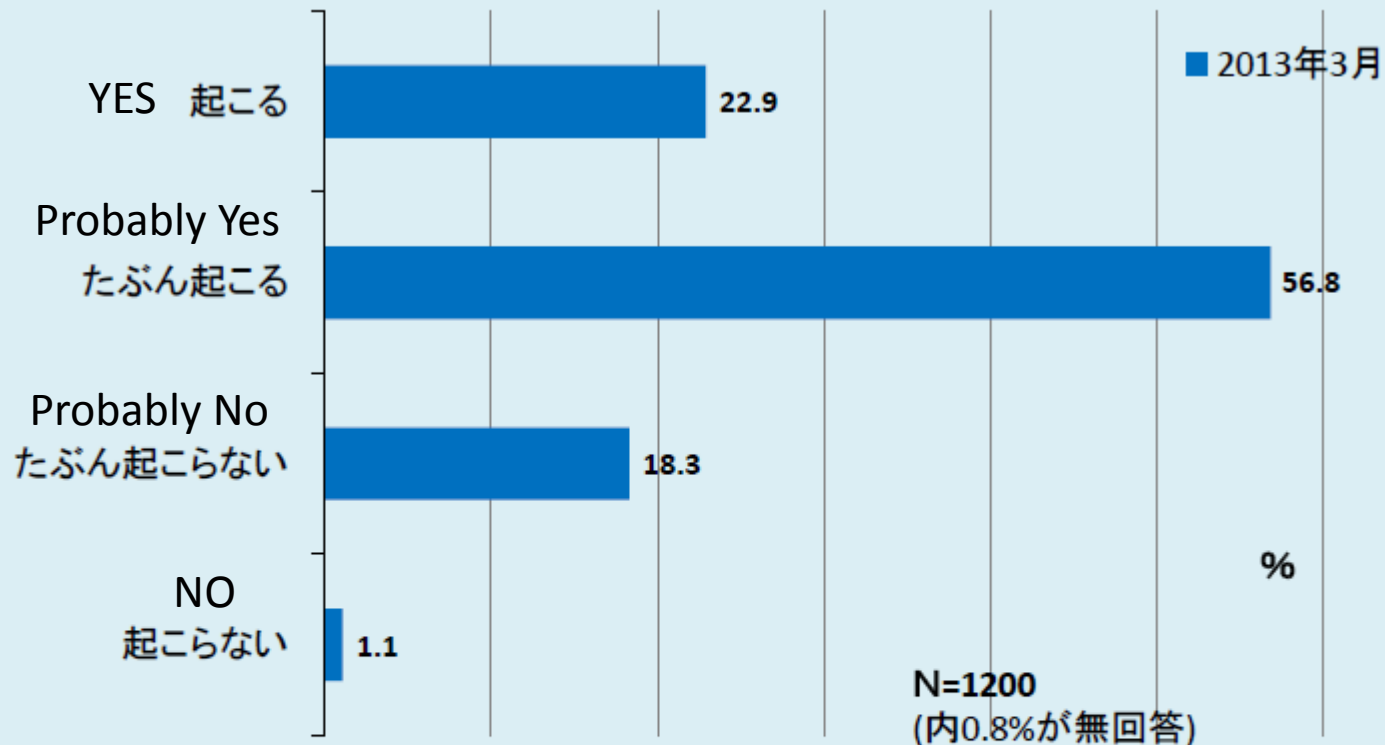




What sources do you think are most “untrustworthy”?

Source: Prof. Hirofumi Hirose, “Changes of Public Opinion about Nuclear Power,”  
Presented at Japan Atomic Energy Commission, July 17, 2013

<http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2013/siryo27/siryo2.pdf>



Do you think a similar scale of nuclear accident will happen again?

## 各地の原発再稼働で 福島第一原発と同程度の事故が起きる可能性

Source: Prof. Hirotsada Hirose, "Changes of Public Opinion about Nuclear Power,"  
Presented at Japan Atomic Energy Commission, July 17, 2013

<http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2013/siryo27/siryo2.pdf>

# Summary of Innovative Energy and Environmental Strategy (2012/09/14)

1. Realization of a society not dependent on nuclear power in earliest possible future (see the next pages)
2. Realization of a green energy revolution
  - Compose the “Framework for Green Development Policy” by the end of this year
  - (1) Power saving: more than 110 billion kWh (~10%) by 2030
  - (2) Energy saving: more than 77 million kl (~19%) by 2030
  - (3) Renewable energy: more than 300 billion kWh (three times) by 2030
3. Stable supply of energy
  - (1) Intensive use of thermal generation
  - (2) Intensive use of heat, including cogeneration
  - (3) Technologies related to the next generation energy
  - (4) Stable and inexpensive securement and supply of fossil fuels
4. Reform of the electric power system
5. Steady implementation of measures against global warming

Source: The Energy and Environment Council, “Innovative Strategy for Energy and Environment,” September 14, 2012.  
[http://www.cas.go.jp/jp/seisaku/npu/policy09/pdf/20120914/20120914\\_1.pdf](http://www.cas.go.jp/jp/seisaku/npu/policy09/pdf/20120914/20120914_1.pdf)



# Summary of New Energy and Environmental Strategy (2012/09/14) (on nuclear energy policy)

Realization of “Society not dependent on nuclear power” in earliest possible future

: Mobilize all possible policy resources to such a level as to even enable zero operation of nuclear power plants in the 2030s.

(1) 3 Principle guidelines

- Strictly apply 40-year limitation of reactor operation
- Restart the operation of nuclear power plants once the Nuclear Regulation Authority gives safety assurance
- Not to plan the new and additional construction of a nuclear power plant

(2) 5 policies to achieve society without dependent on nuclear power (later)

(3) Review and constantly re-examine the path towards realization of a society not dependent on nuclear power

Source: The Energy and Environment Council, “Innovative Strategy for Energy and Environment,” September 14, 2012. [http://www.cas.go.jp/jp/seisaku/npu/policy09/pdf/20120914/20120914\\_1.pdf](http://www.cas.go.jp/jp/seisaku/npu/policy09/pdf/20120914/20120914_1.pdf)



# PM Abe's Statement at Diet on Energy Policy (2013/02/28)

- Reflecting on the accident at Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station, under the Nuclear Regulation Authority, **we will foster a new culture of safety that will uncompromisingly enhance the degree of safety.** After doing so **we will restart nuclear power plants where safety has been confirmed.**
- **We will promote the introduction of energy conservation and renewable energies to the greatest possible extent to reduce our degree of dependency on nuclear power as much as possible.** At the same time, we will begin **a fundamental reform of the electric system.**

[http://www.kantei.go.jp/foreign/96\\_abe/statement/201302/28siseuhousin\\_e.html](http://www.kantei.go.jp/foreign/96_abe/statement/201302/28siseuhousin_e.html)



# Impact on Global Nuclear Energy Development

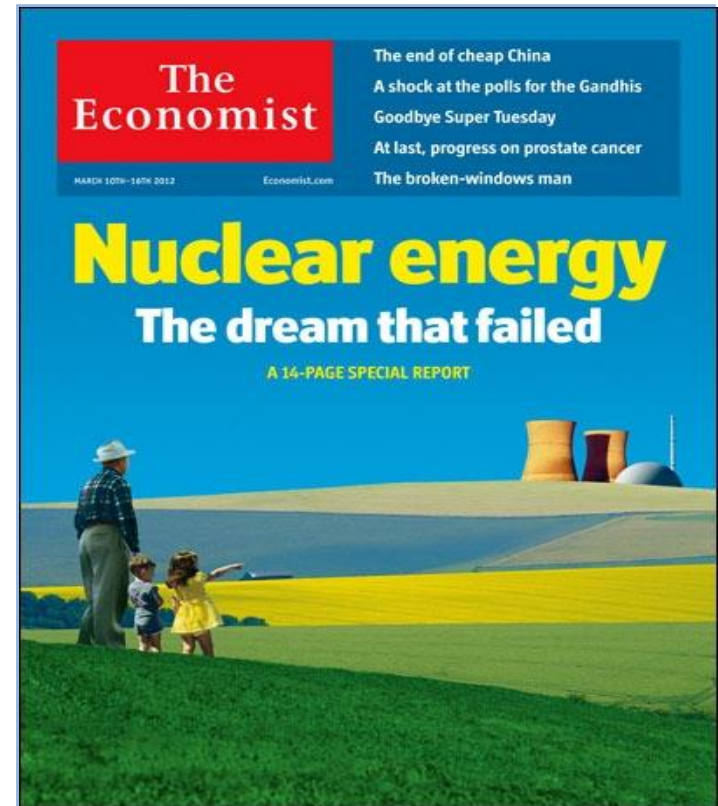


# From “Nuclear Renaissance” to “Failed Dream”? by “The Economist”



*“A nuclear revival is welcome so long as the industry does not repeat its old mistakes”*

*-- The Economist, September 8, 2007*

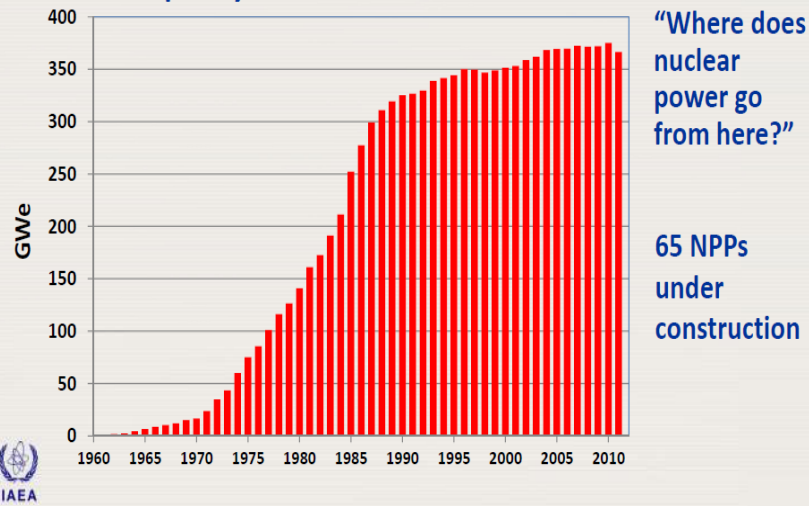


*“For nuclear to play a greater role, either it must get cheaper or other ways of generating electricity must get more expensive.”– The Economist, March 10, 2012*

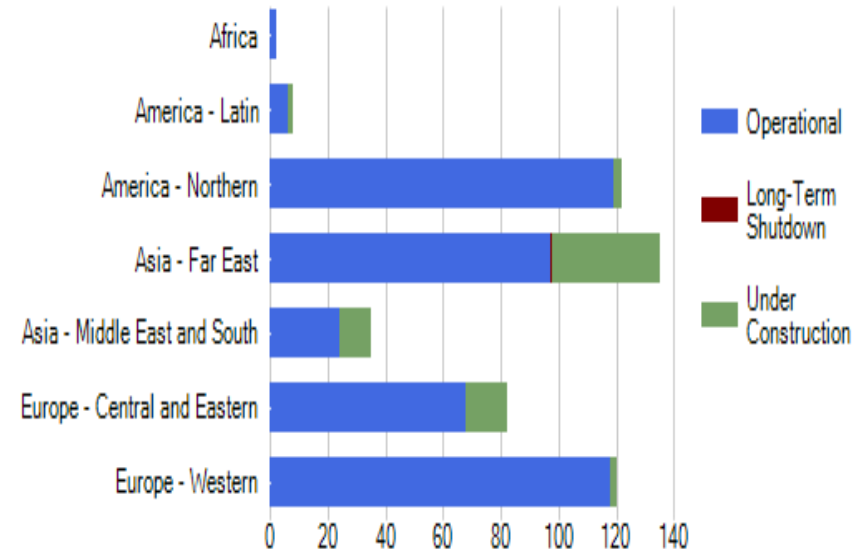
# Global Nuclear Power Development Current Status (IAEA)

## Nuclear power today

On 21 November 2011, 443 nuclear power plants (NPPs) operated in 30 countries worldwide, with a total installed capacity of 366.6 GWe.



## Total Number of Reactors



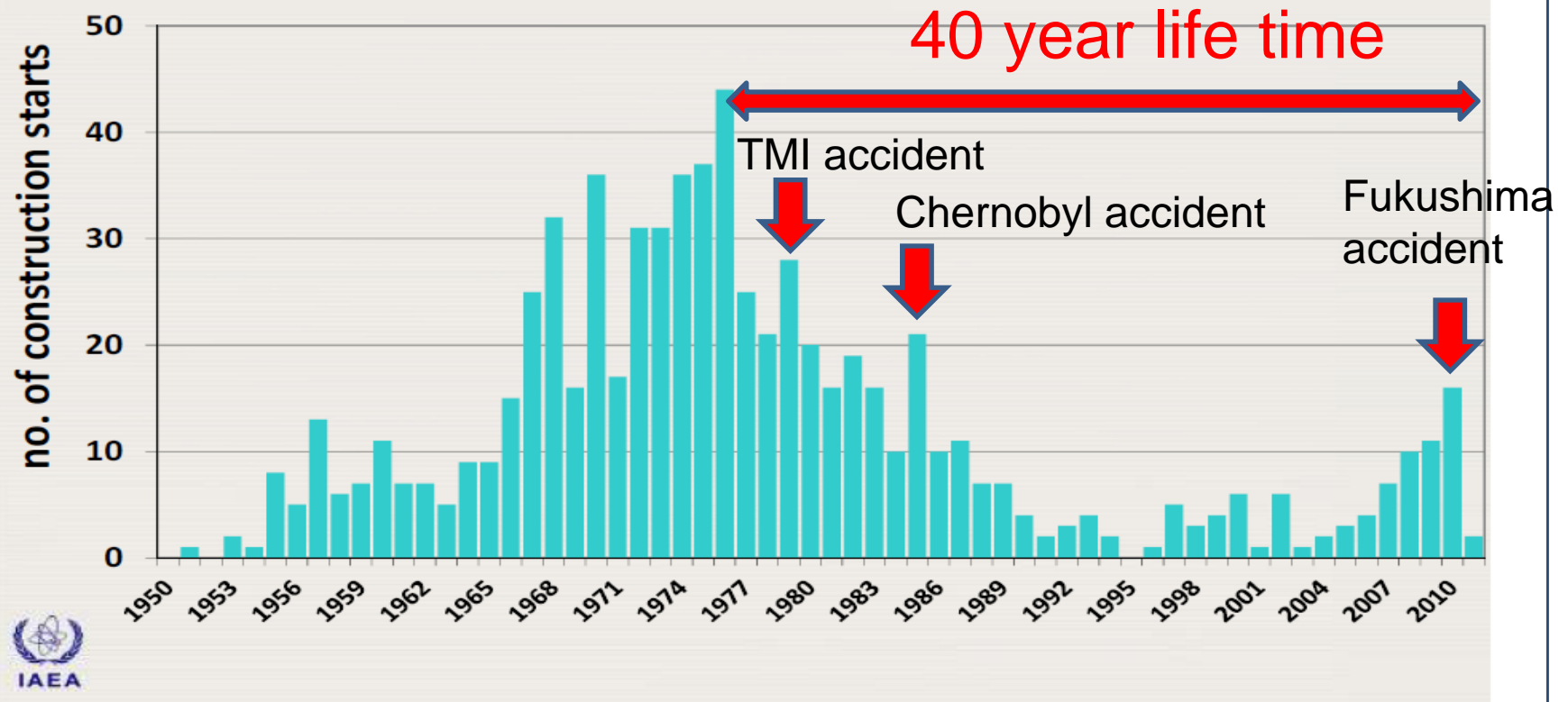
Source: H-HolgerRogner, Head, Planning & Economic Studies Section (PESS) Department of Nuclear Energy, International Atomic Energy Agency, "Energy, Electricity and Nuclear Power Estimates for the Period up to 2030," November 2011.

As of July 31, 2013, 434 nuclear power plants (370.5 GWe) are operating and 69 units are under construction, one unit in long term shutdown. <http://www.iaea.org/pris/>



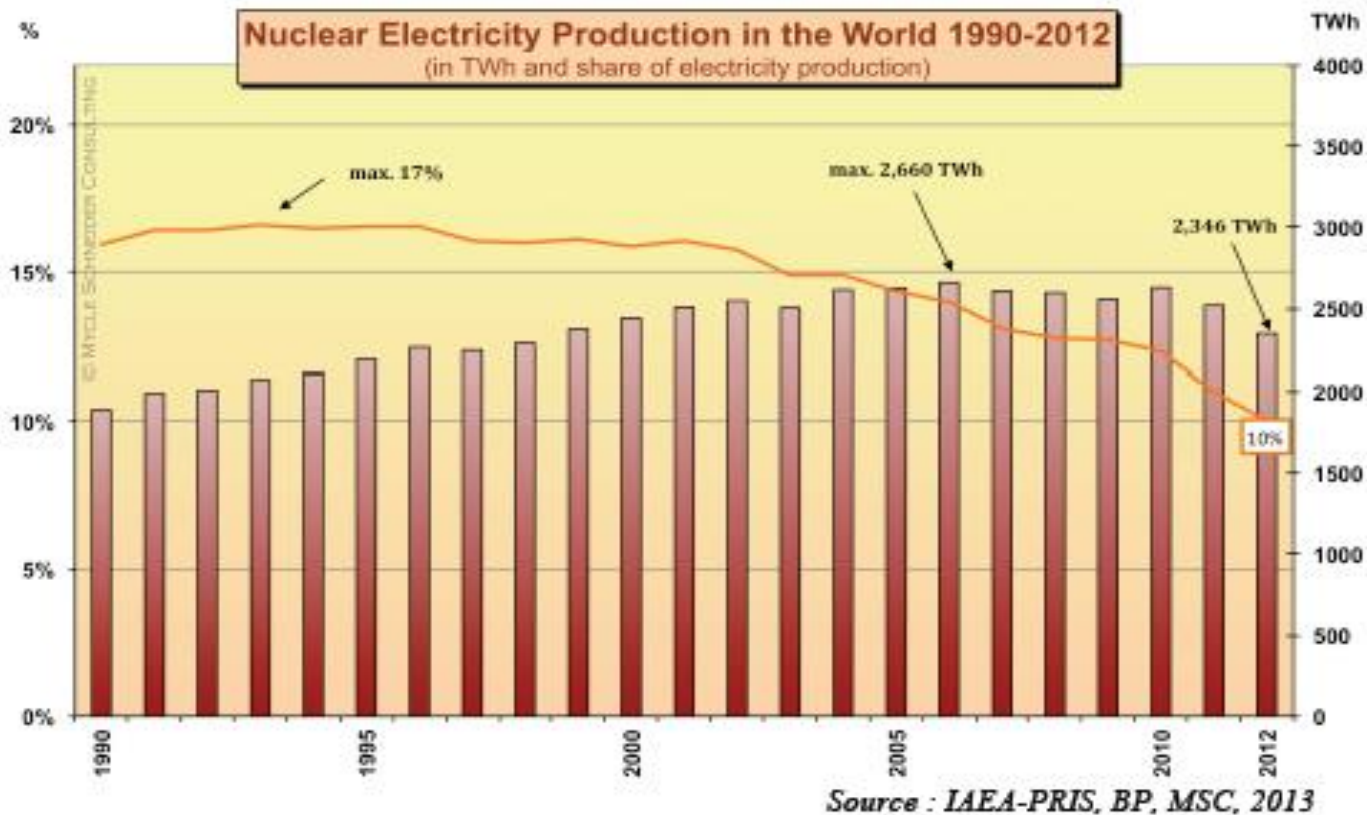
# Global Nuclear Power Plant Construction (IAEA) : Replacement of old reactors are coming....

## Construction starts



# Global Nuclear power production is in decline

Figure 1: Nuclear Electricity Generation in the World



# Asia: No major policy changes, still committed to nuclear power

**Bangladesh:** There is **no change** in plans to promote nuclear policy. Bangladesh signs with agreement between Russia about the construction of Rooppur NPP in November 2011.

**China:** Important role of nuclear power in China **is not changed**. China has temporarily stopped the authorization of new projects after the accident, but the construction of NPP has restarted now.

**India:** Domestic energy demand is increasing, and nuclear power is considered to be an important option as a clean energy source (**no change**). Construction of new NPPs are progressing according to the existing plan.

**Indonesia:** 49.5% of the population is **in favor (35.5% opposition)** for against nation's nuclear policy. Nuclear power is considered as one of the main power source to support energy security.

**Kazakhstan:** There is **no change** in plans to promote nuclear power. many people are aware that there is no other option to incorporate nuclear power for the realization of nation's policy.

**South Korea:** There is **no change** in nuclear policy. Based on the "4th Comprehensive Nuclear Energy Promotion Plan", South Korea continues to build NPPs in six locations from 2012 to 2017.

**Malaysia:** There is **no change** in plans to begin the operation of Malaysia's first nuclear reactor in 2021.

**Vietnam:** There is **no change** in plans to promote nuclear power. Vietnam plans to build high safety NPPs learned from Fukushima accident with Japan and Russia in cooperation.

**Taiwan:** Announced an energy policy to **reduce the dependence** on nuclear power.

**Thailand:** **Decided the postponement** of the plan to build five NPPs for 3 years.



# Estimates of Nuclear Electrical Generating Capacity :

## Comparison of estimates in 2012 and 2011

	Actual in 2011	Estimates for 2030		Estimates for 2050	
		Estimated in 2011	in 2012	Estimated in 2011	in 2012
<b><u>World Total</u></b>					
Nucl. Capacity (GWe)			-9%		-16%
Low Estimate	368.8	501	456	560	469
High Estimate		746	740	1228	1137
Share (%)			-1%		-7%
Low Estimate	7.1	5.2	4.7	2.7	2.3
High Estimate		6.2	6.2	6.0	5.7
<b><u>Far East</u></b>					
Nucl. Capacity (GWe)			-15%		-13%
Low Estimate	79.8	180	153	220	191
High Estimate		255	274	450	417
Share (%)			+7%		-7%
Low Estimate	5.0	6.4	5.5	4.2	3.7
High Estimate		7.5	8.2	8.6	8.1

Source: International Atomic Energy Agency, "Energy, Electricity and Nuclear Power Estimates for the Period up to 2050," 2011 Edition [http://www-pub.iaea.org/MTCD/Publications/PDF/RDS1\\_31.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/RDS1_31.pdf)  
2012 Edition [http://www-pub.iaea.org/MTCD/Publications/PDF/IAEA-RDS-1-32\\_web.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/IAEA-RDS-1-32_web.pdf)



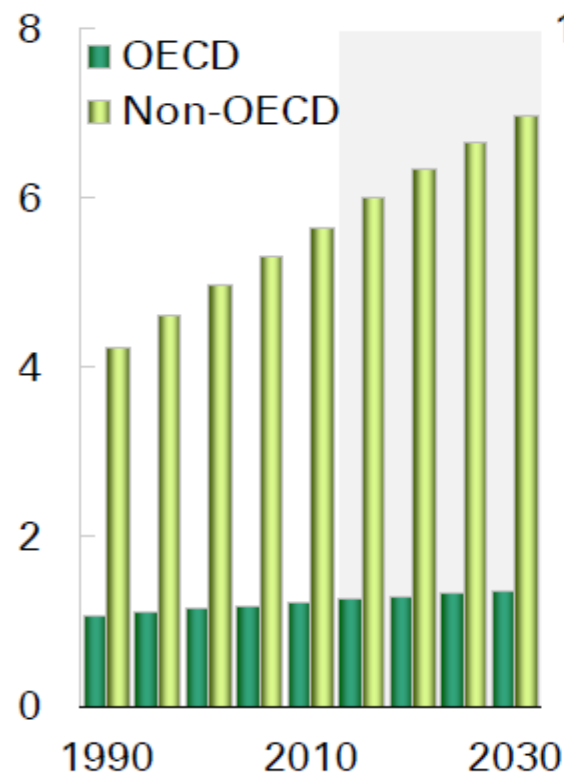
# Global Energy Trends



# Population and income growth...

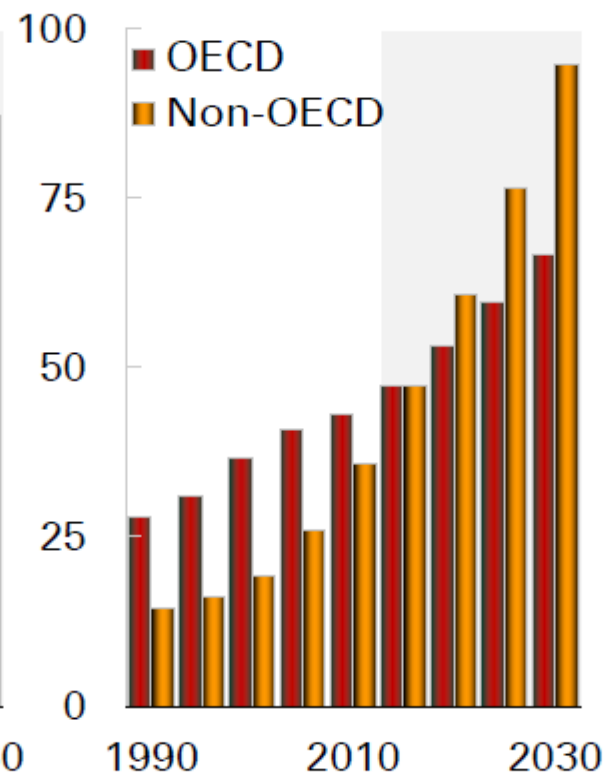
## Population

Billion



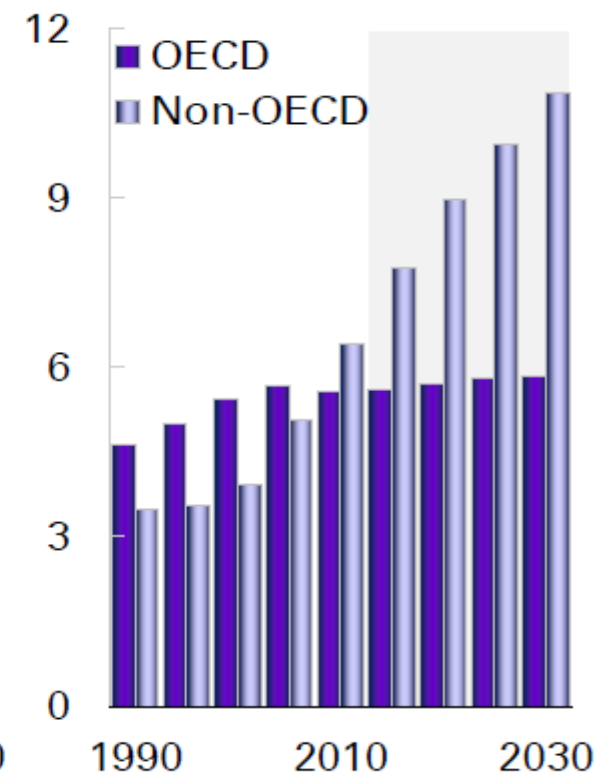
## GDP

Trillion \$2011

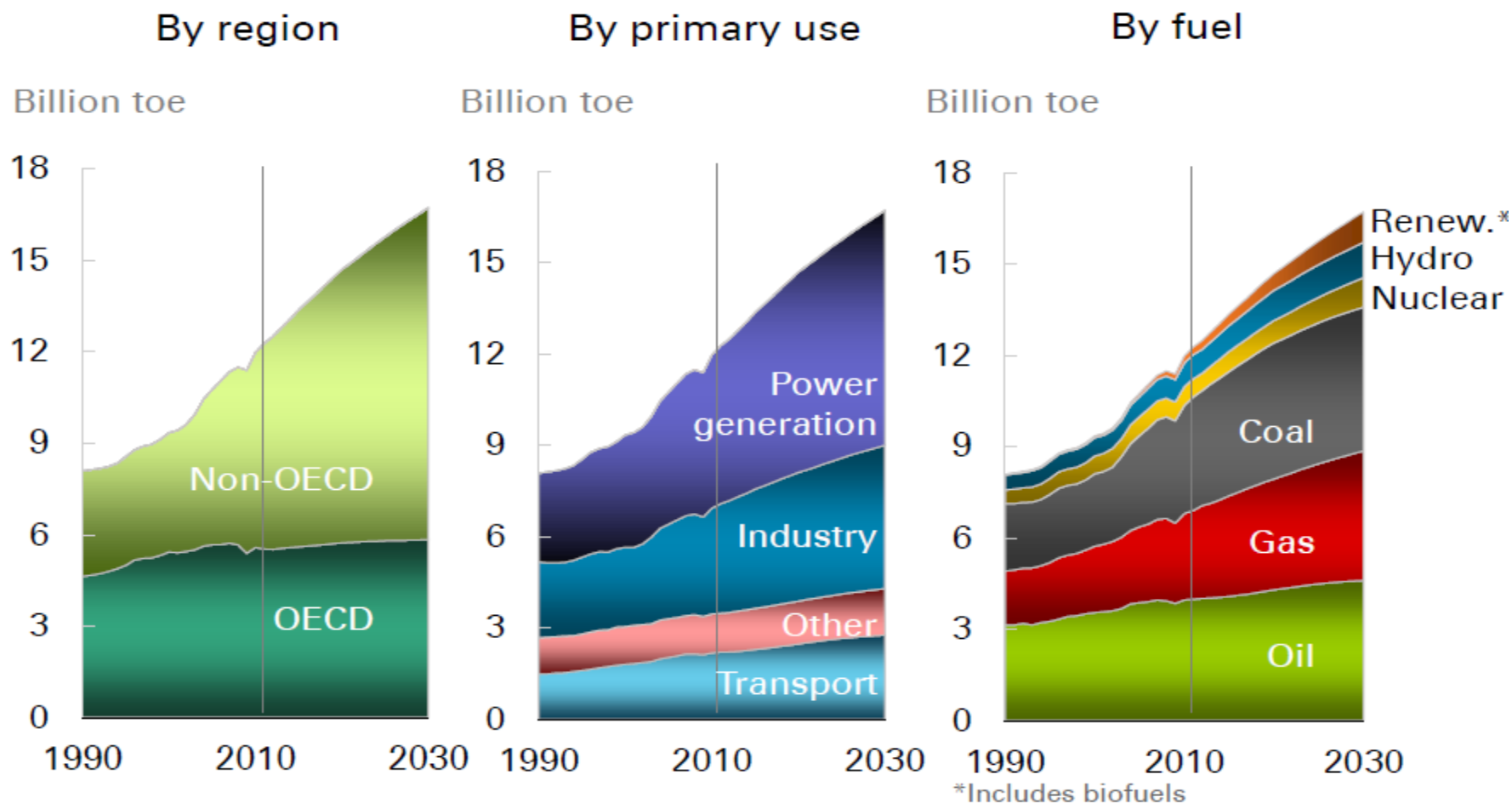


## Primary energy

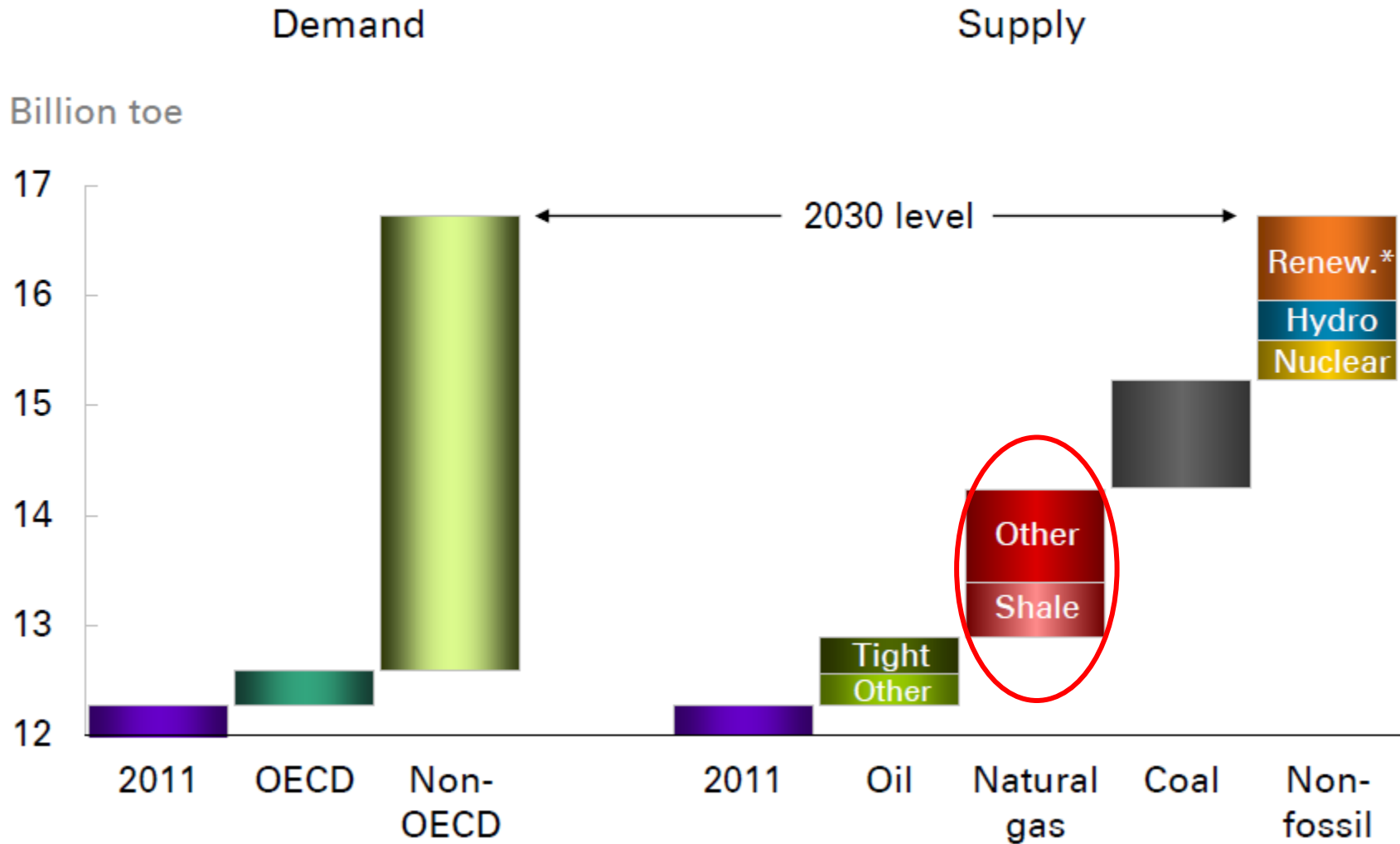
Billion toe



# Industrialisation and growing power demand...



# Energy demand growth is matched by supply...



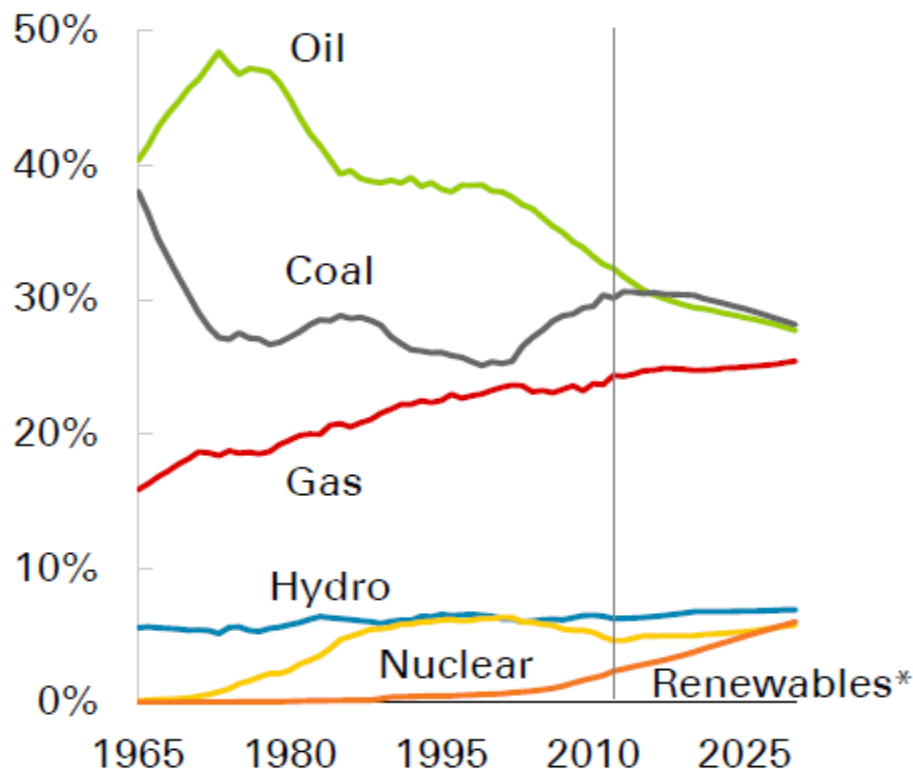
\*Includes biofuels





## Energy prices play a key role...

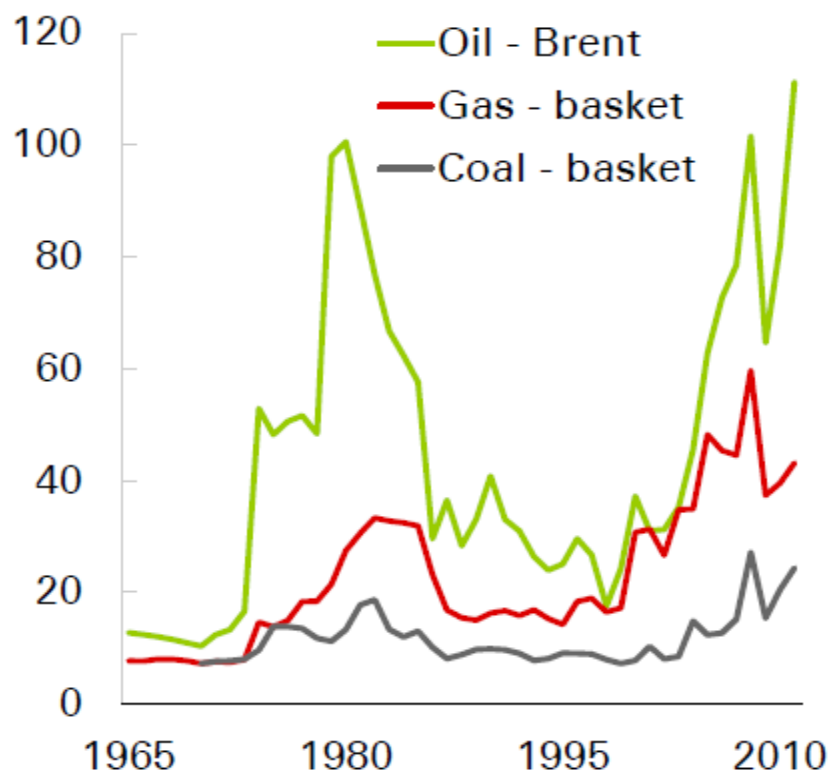
### Shares of world primary energy



\*Includes biofuels

### Energy prices

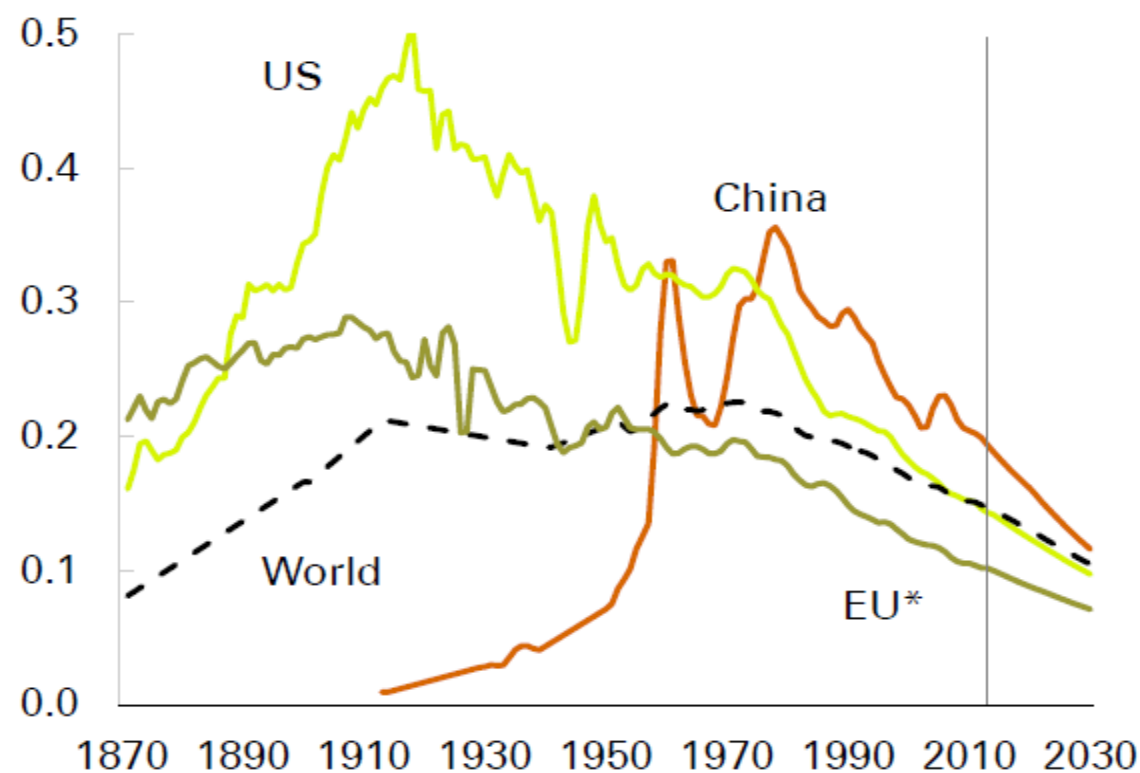
\$2011/boe



# Energy efficiency improvements are critical...

## Energy intensity by region

Toe per thousand \$2011 GDP

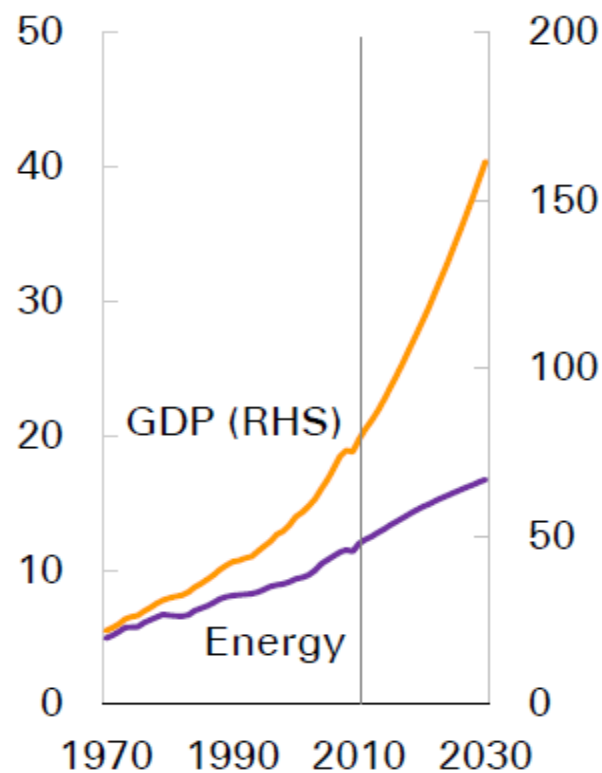


\*Euro4 (France, Italy, Germany, UK) pre-1970

## Energy and GDP

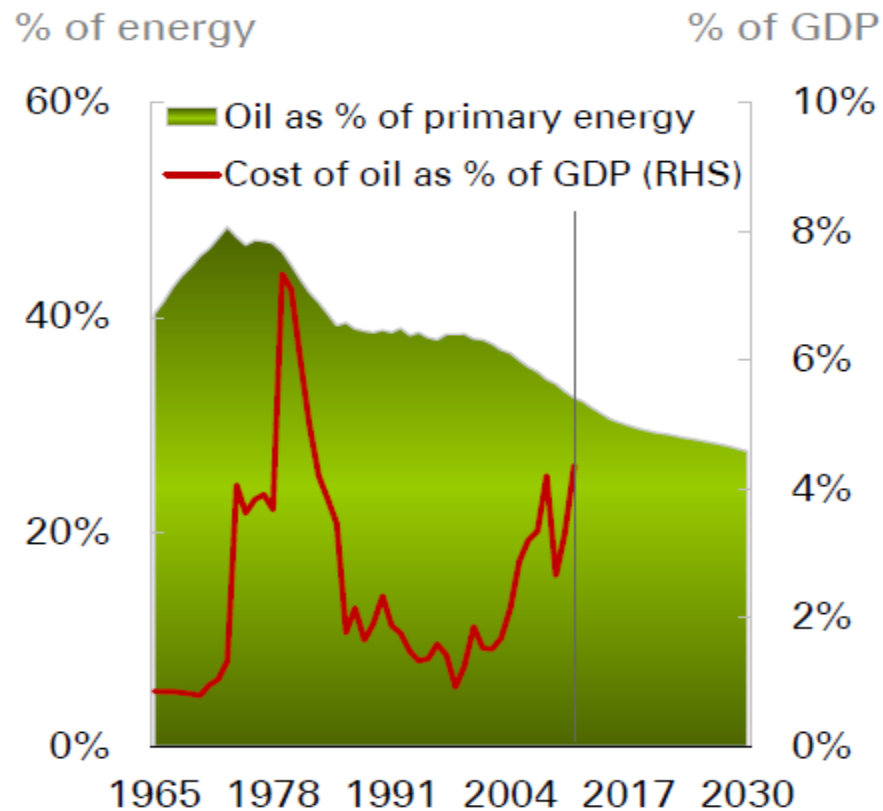
Billion toe

Trillion \$2011

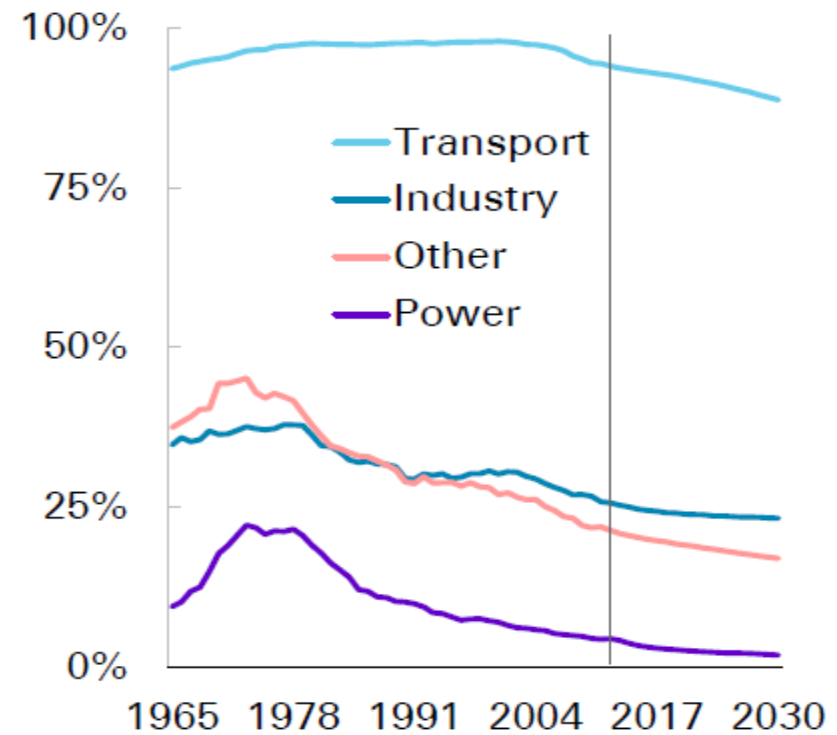


# High oil prices are reducing oil's share of primary energy...

## Oil share of energy and GDP



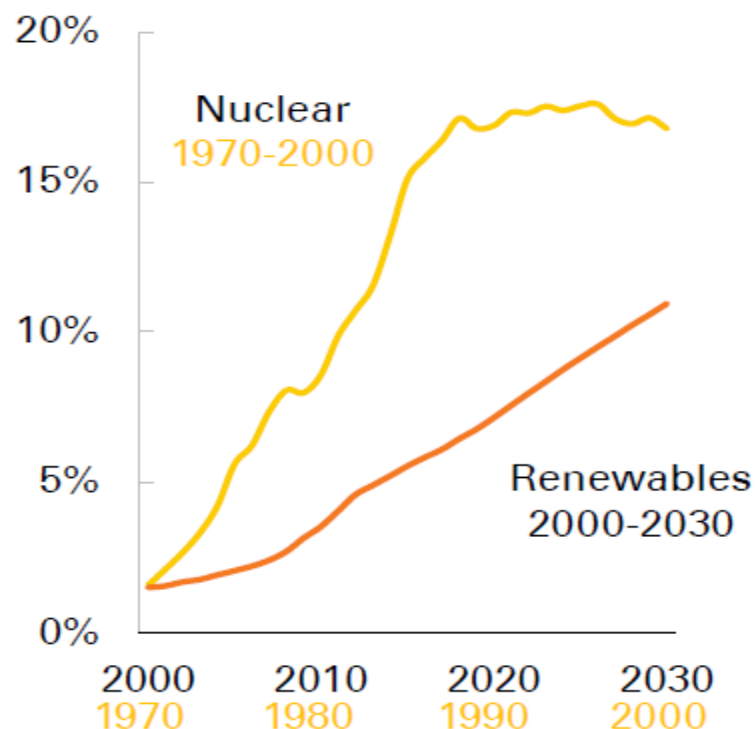
## Oil share in sector





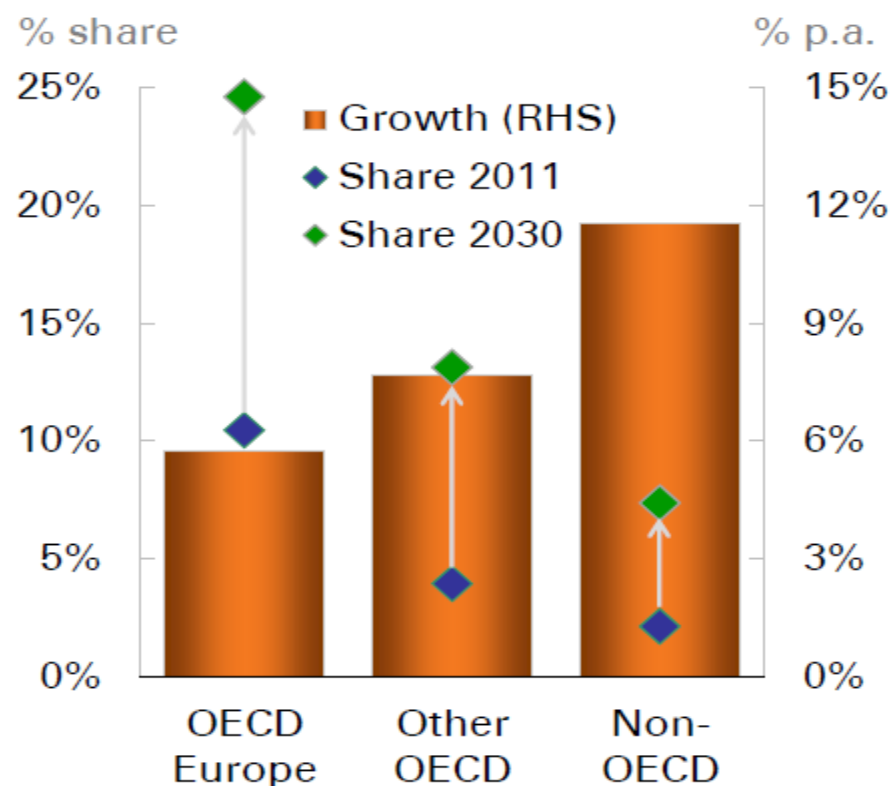
## Renewables continue to gain market share...

### Share of power generation



### Renewable power

Growth 2011-30, and share of power

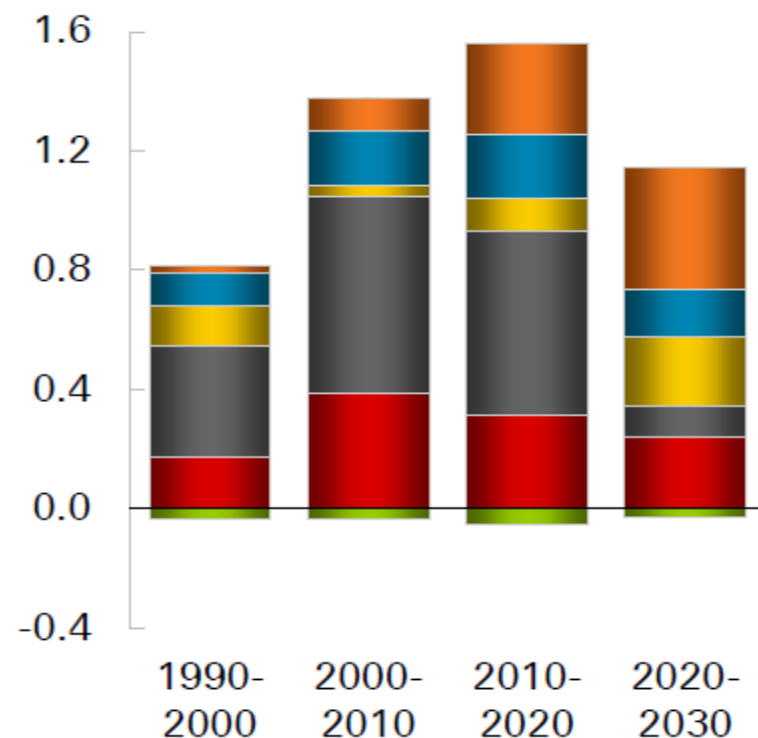




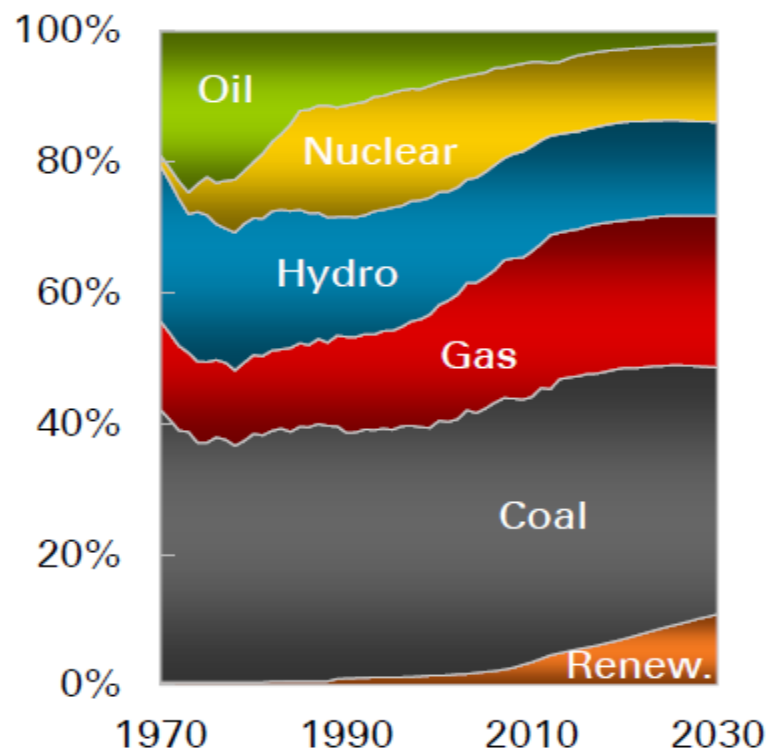
## The fuel mix for power generation diversifies...

Growth of fuel inputs to power

Billion toe



Shares of power output



# Energy Technology Strategy for Sustainable Future

From International Energy Agency  
“Energy Technology Perspective  
2012”

<http://www.iea.org/etp/etp2012/presentations/>



# ETP 2012 – Choice of 3 Futures

## 2DS

a vision of a **sustainable** energy system of reduced Greenhouse Gas (GHG) and CO<sub>2</sub> emissions

**The 2°C Scenario**

## 4DS

reflecting pledges by countries to cut emissions and boost energy efficiency

**The 4°C Scenario**

## 6DS

where the world is now heading with potentially **devastating** results

**The 6°C Scenario**



# Sustainable future still in reach

Is a clean energy transition urgent?

**YES ✓**

Are we on track to reach a clean energy future?

**NO ✗**

Can we get on track?

**YES ✓**



# Recommendations to Governments

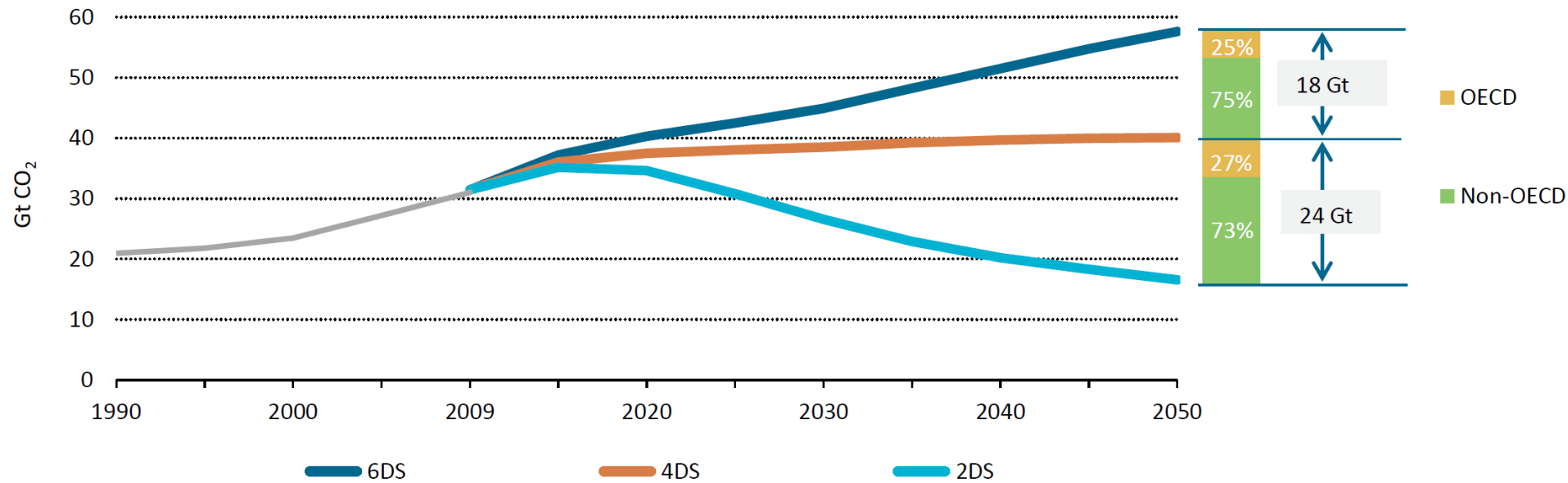
## ETP 2012

1. Create an investment climate of confidence in clean energy

2. Unlock the incredible potential of energy efficiency – “the hidden” fuel of the future

3. Accelerate innovation and public research, development and demonstration (RD&D)

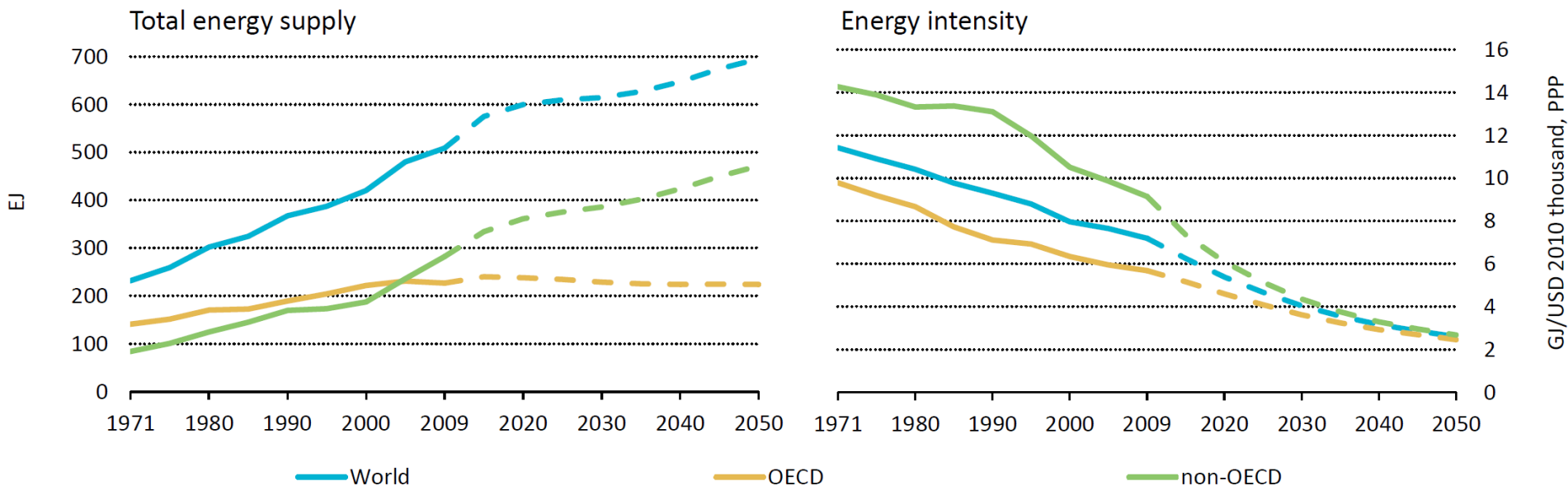
# Choosing the future energy system



*To achieve the 2DS, energy-related CO<sub>2</sub> emissions must be halved until 2050.*



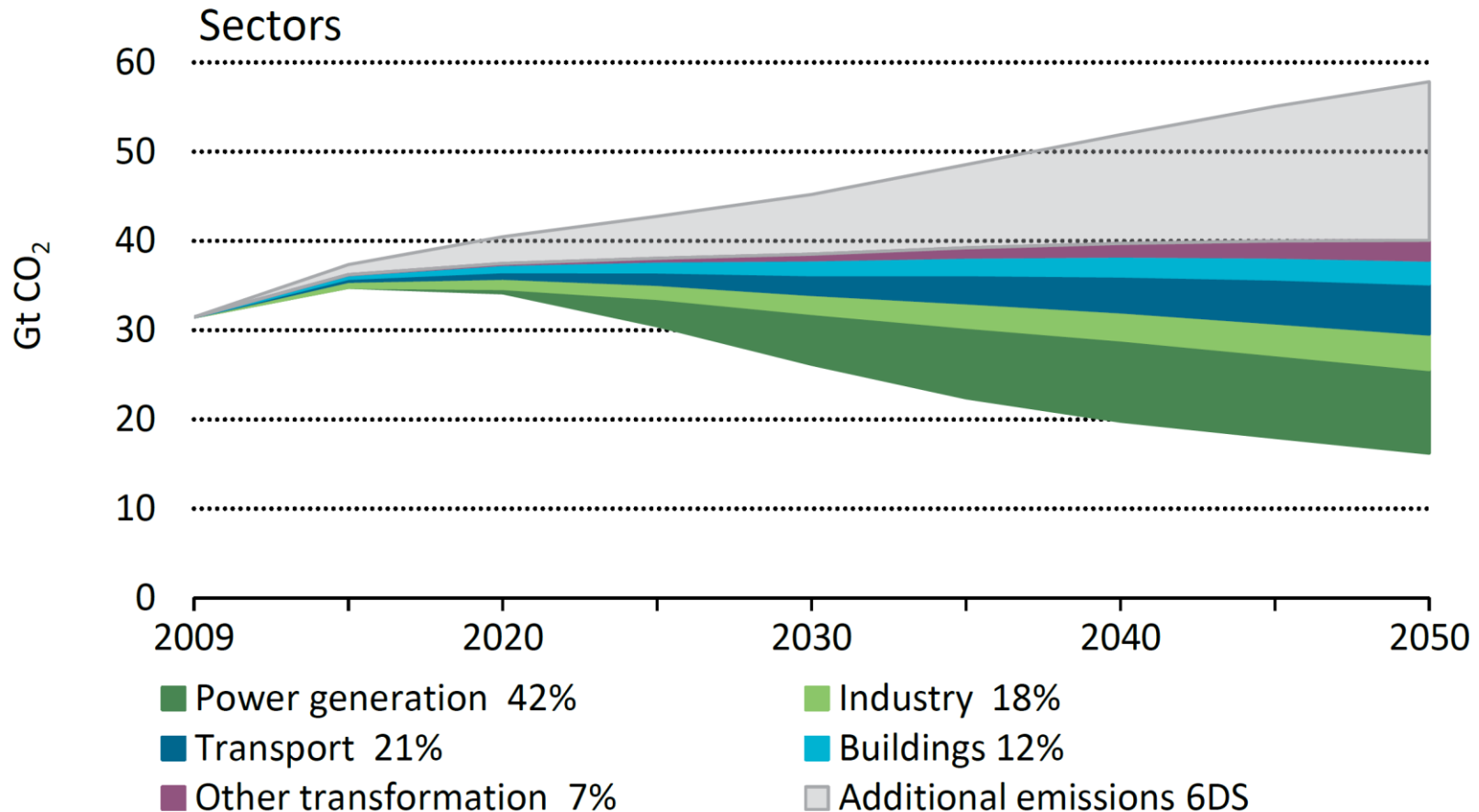
# Decoupling energy use from economic activity



*Reducing the energy intensity of the economy is vital to achieving the 2DS.*



# All sectors need to contribute

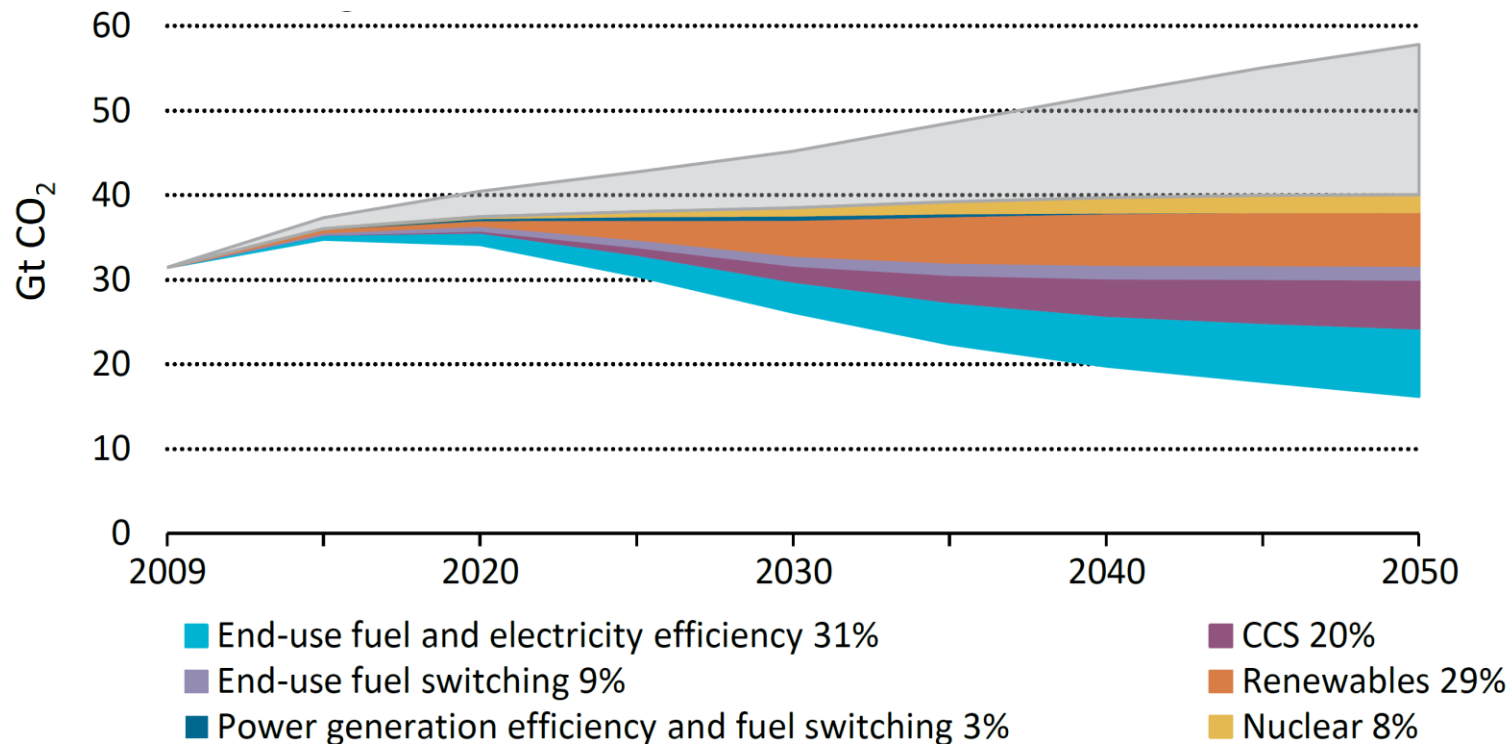


*The core of a clean energy system is low-carbon electricity that diffuses into all end-use sectors.*



# A portfolio of technologies is needed

## Technology contributions to reaching the 2DS vs 4DS



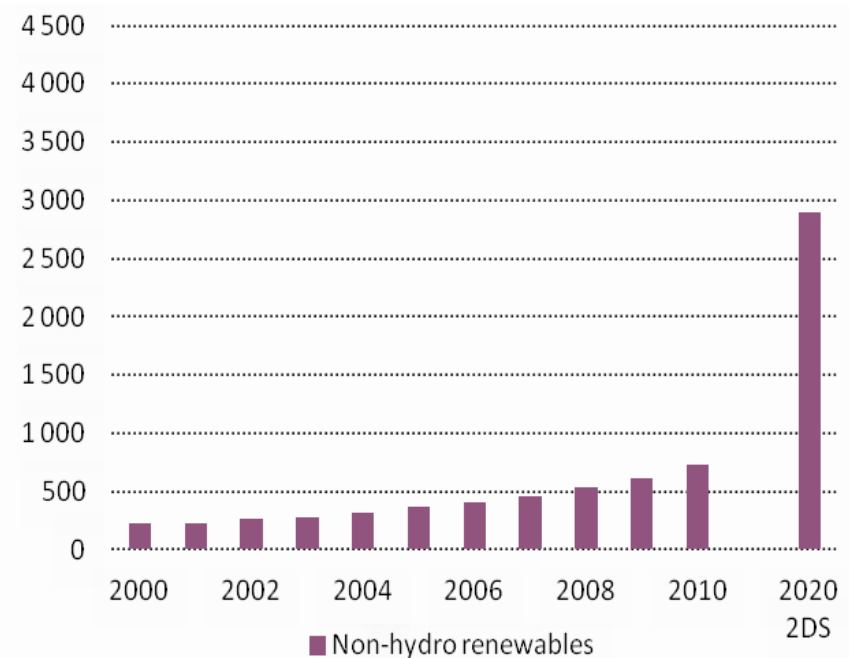
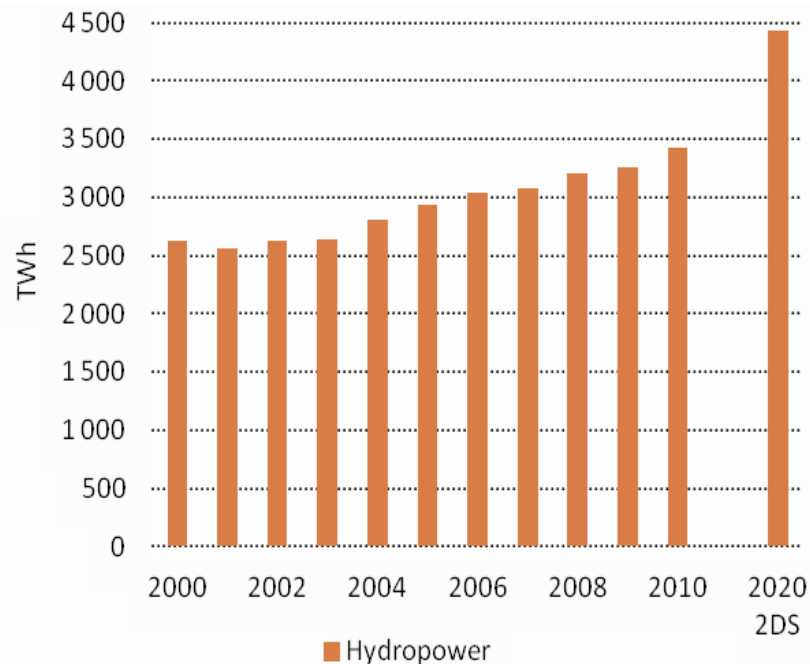
*Energy efficiency is the hidden fuel that increases energy security and mitigates climate change.*



# Renewables provide good news

ETP  
2012

## Global renewable power generation



**42%**

Average annual  
growth in Solar PV

**75%**

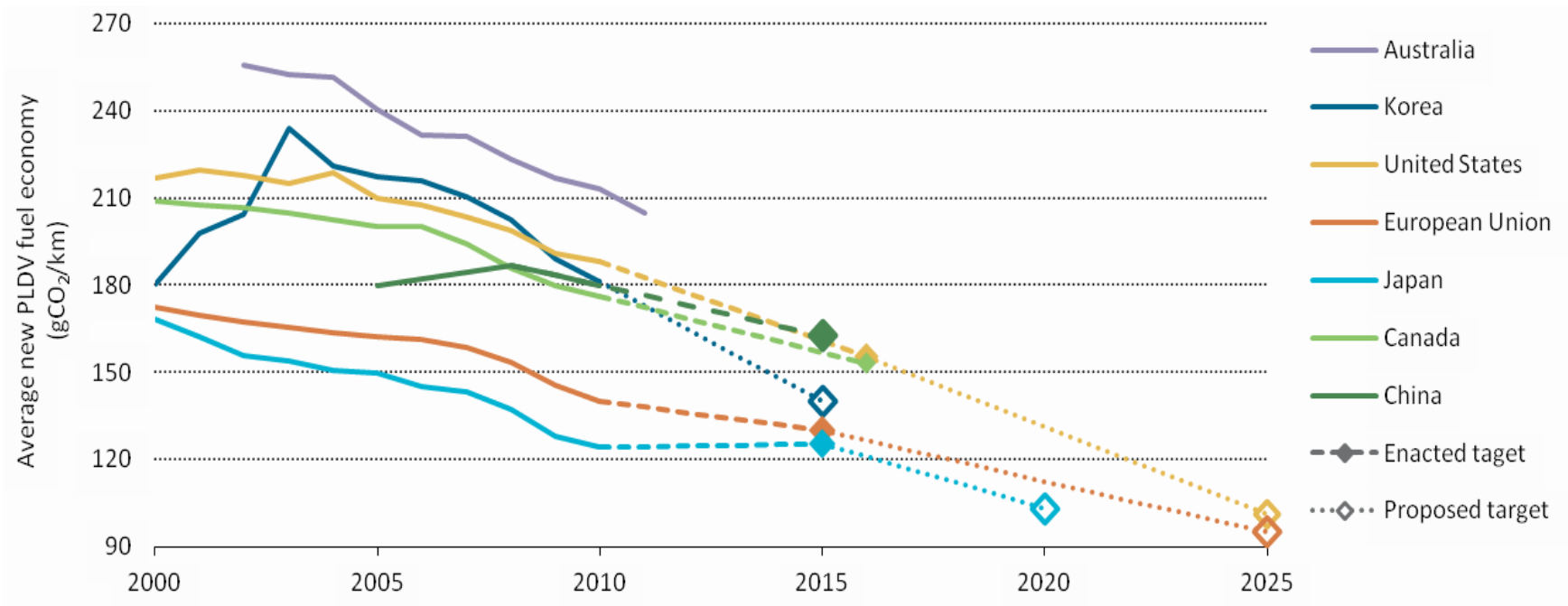
Cost reductions in  
Solar PV in just  
three years in  
some countries

**27%**

Average annual  
growth in wind

# Fuel economy has improved

## Vehicle fuel economy, enacted and proposed standards



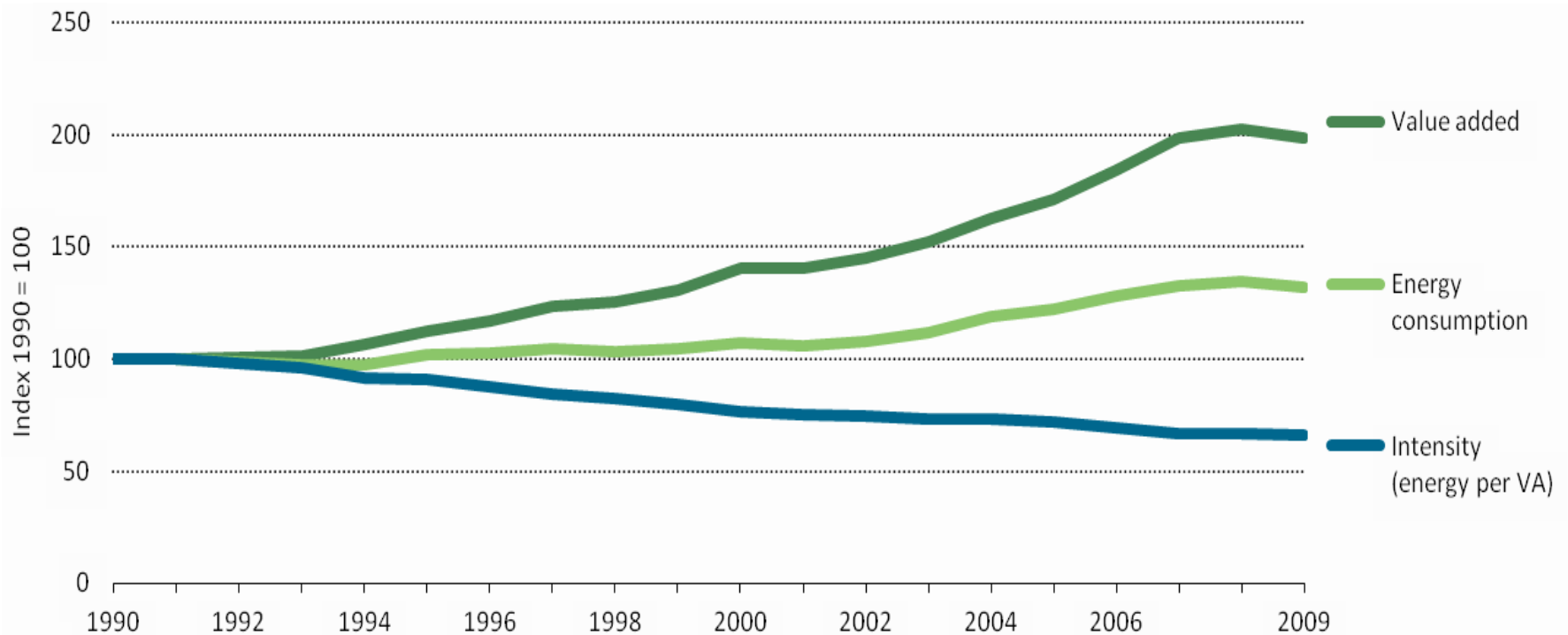
*The number one opportunity over the next decade in the transport sector, but few countries have standards in place.*





# Energy intensity must decline further

## Progress in energy intensity

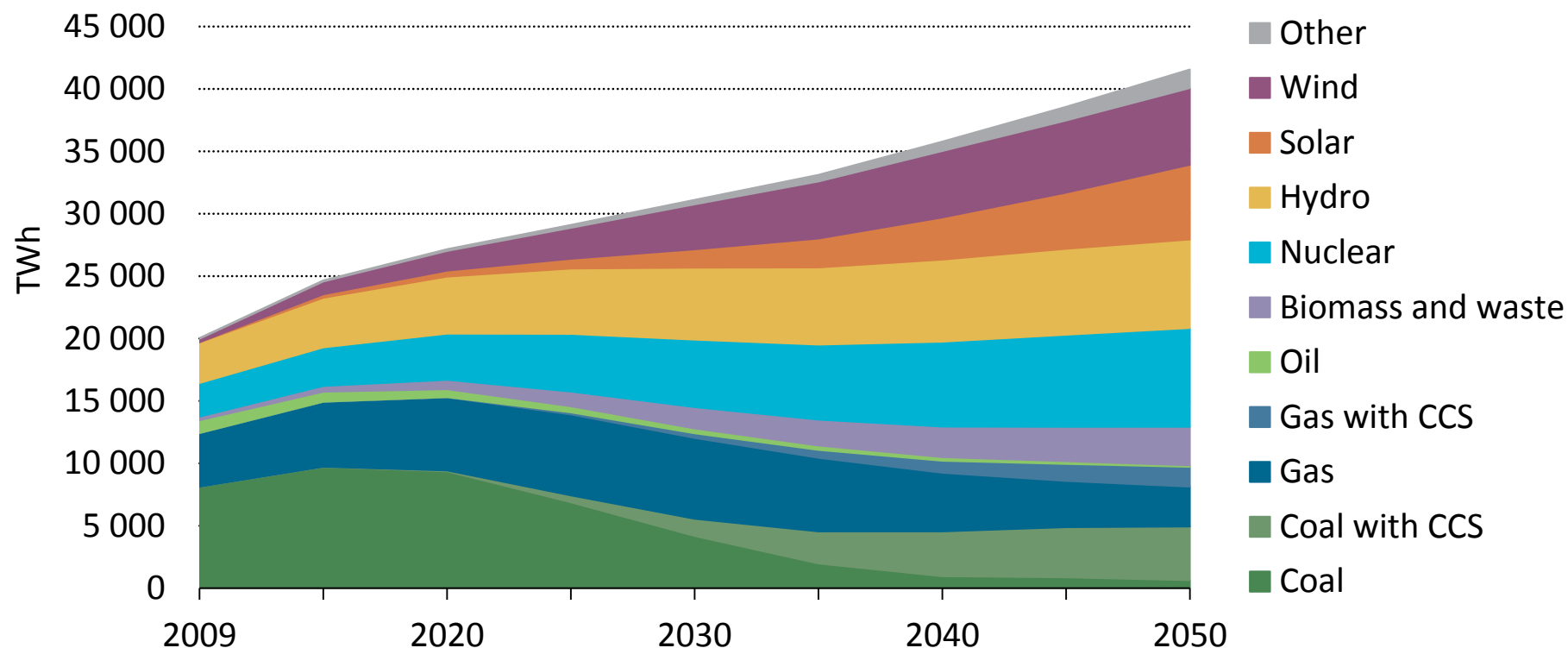


*Significant potential for enhanced energy efficiency can be achieved through best available technologies.*



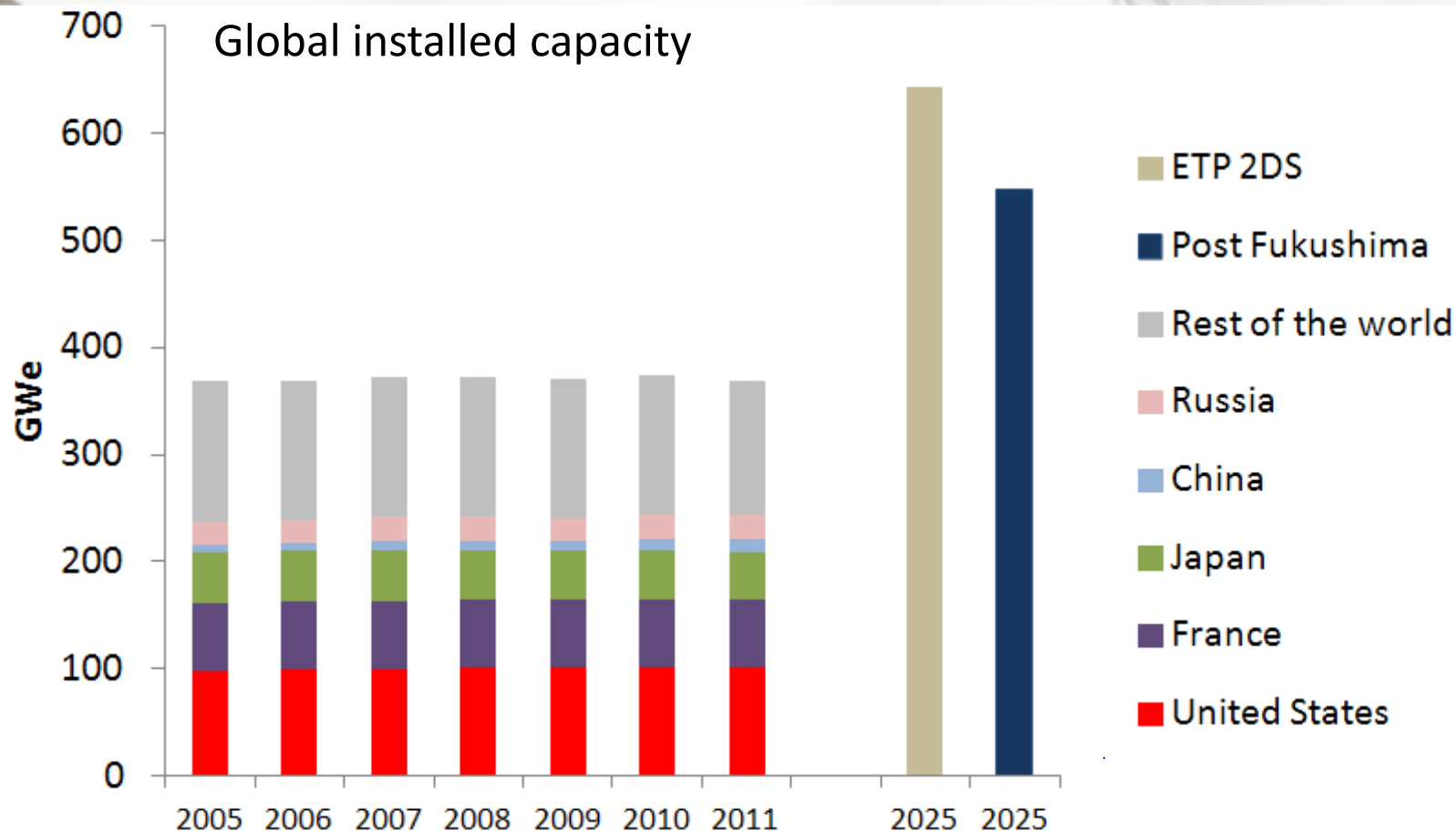
# Low-carbon electricity: a clean core

Global electricity generation in the 2DS



*Renewables will generate more than half the world's electricity in 2050 in the 2DS*

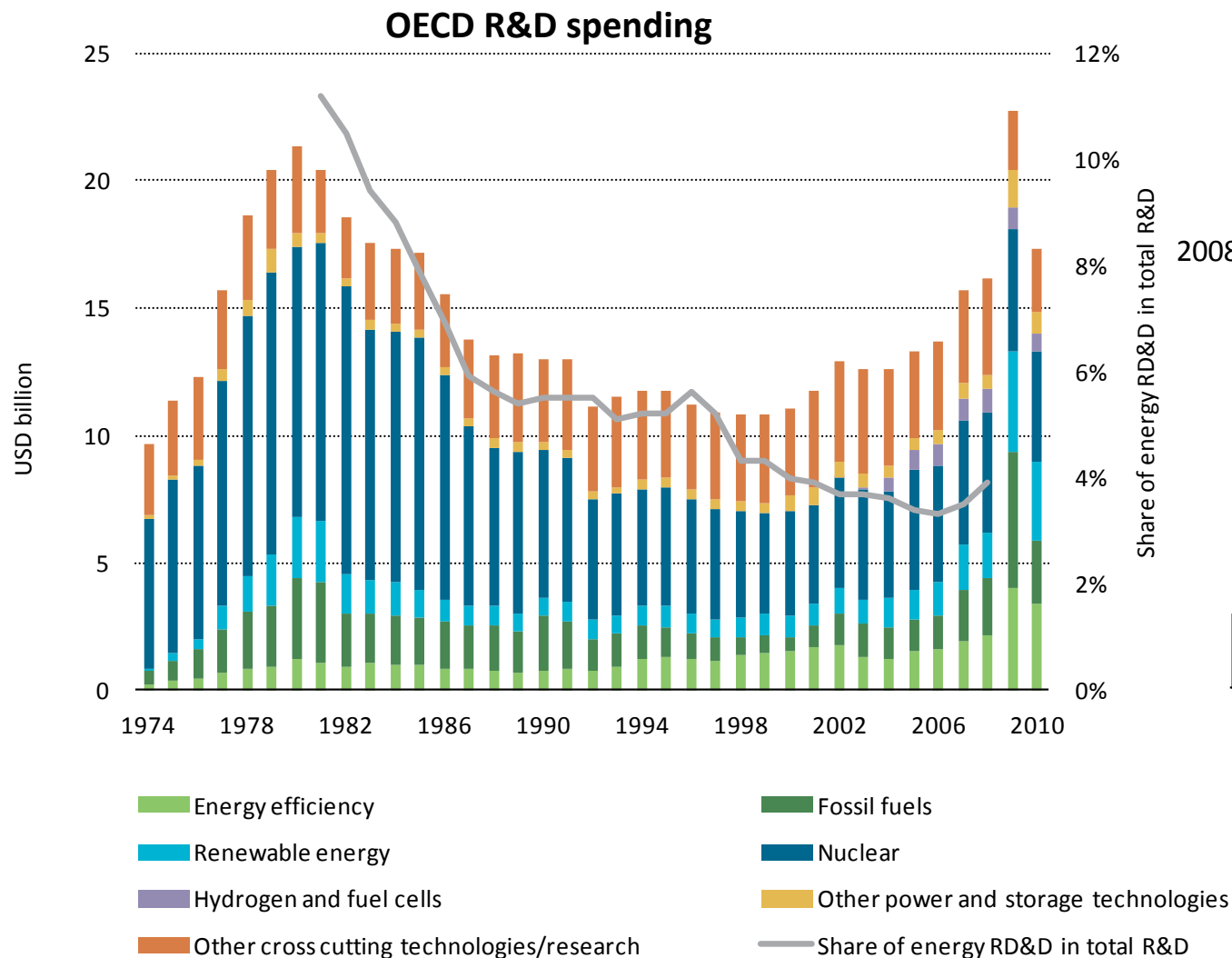
## Power generation; Nuclear



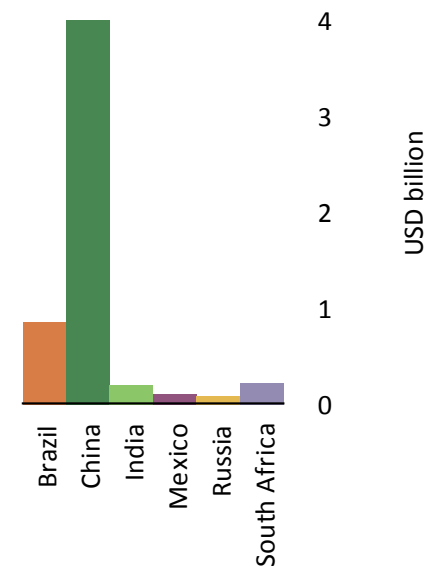
*Without further action, nuclear deployment in 2025 will be below levels in the 2DS, although a majority of key countries remain committed to nuclear.*

# Energy RD&D has slipped in priority

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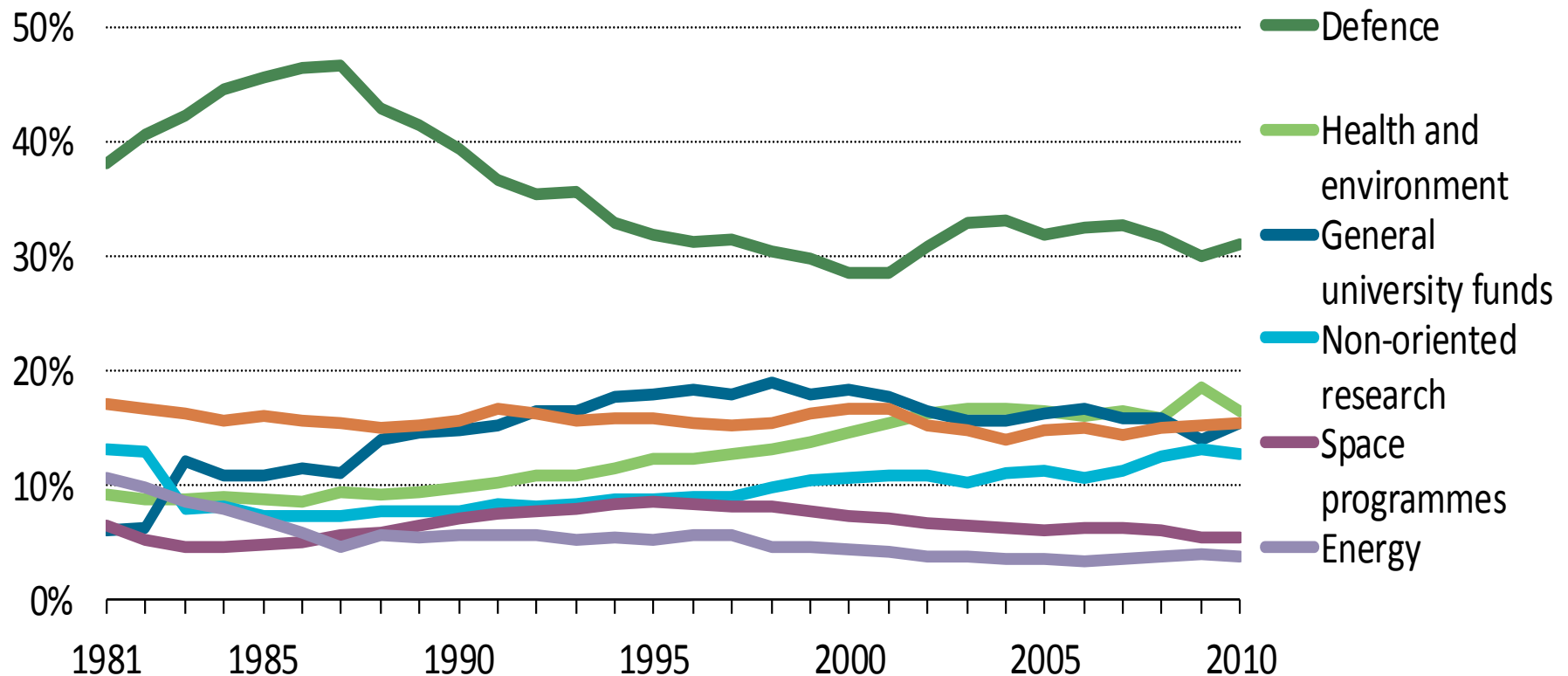


**2008 non-IEA country spending**



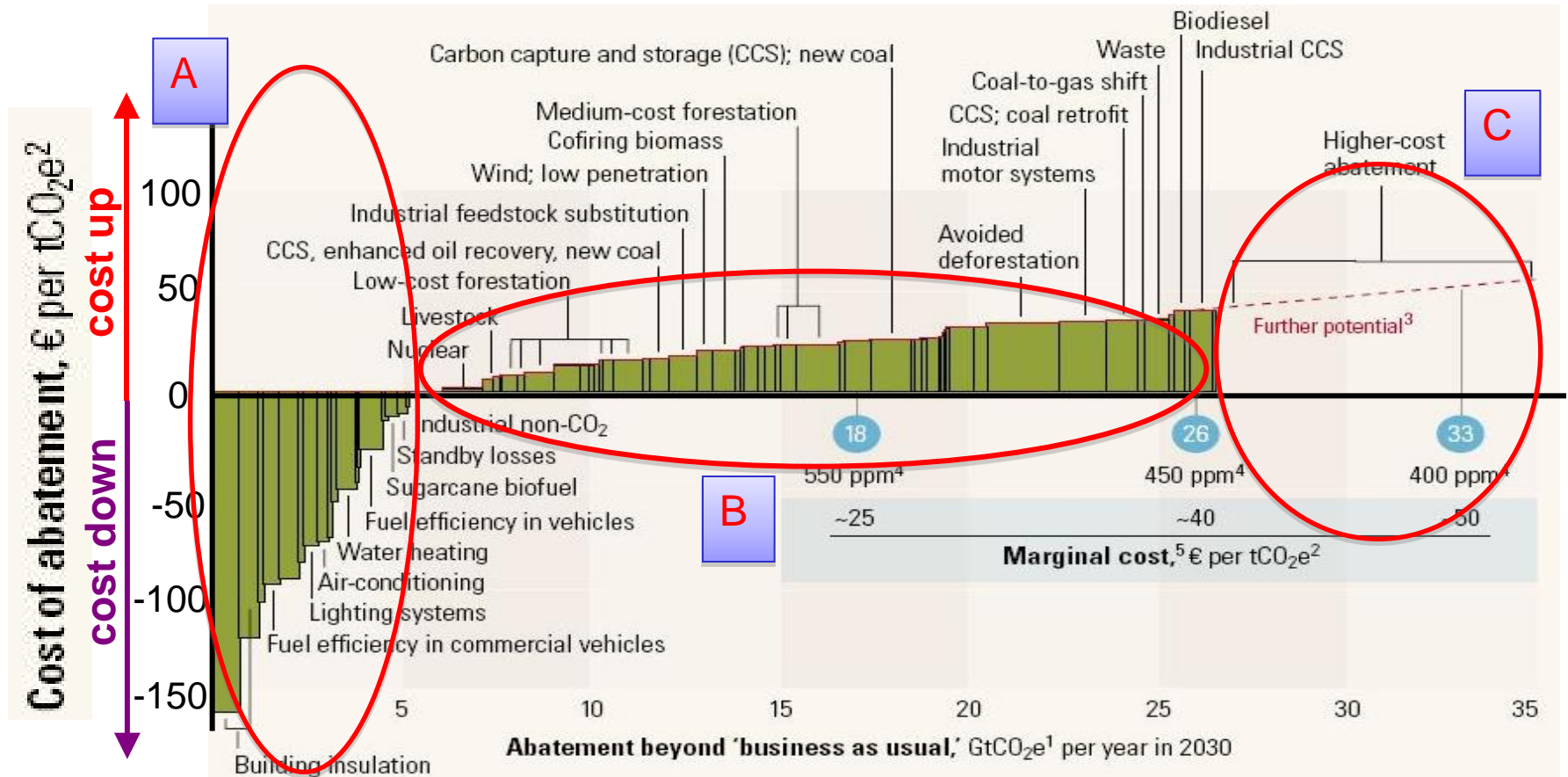
# Energy RD&D has slipped in priority

OECD R&D spending



*The IEA has called for a twofold to fivefold increase in annual public RD&D spending on low carbon technologies to achieve the 2DS.*

# How much can we reduce GHGs and how much do they cost? (Global, 2007)

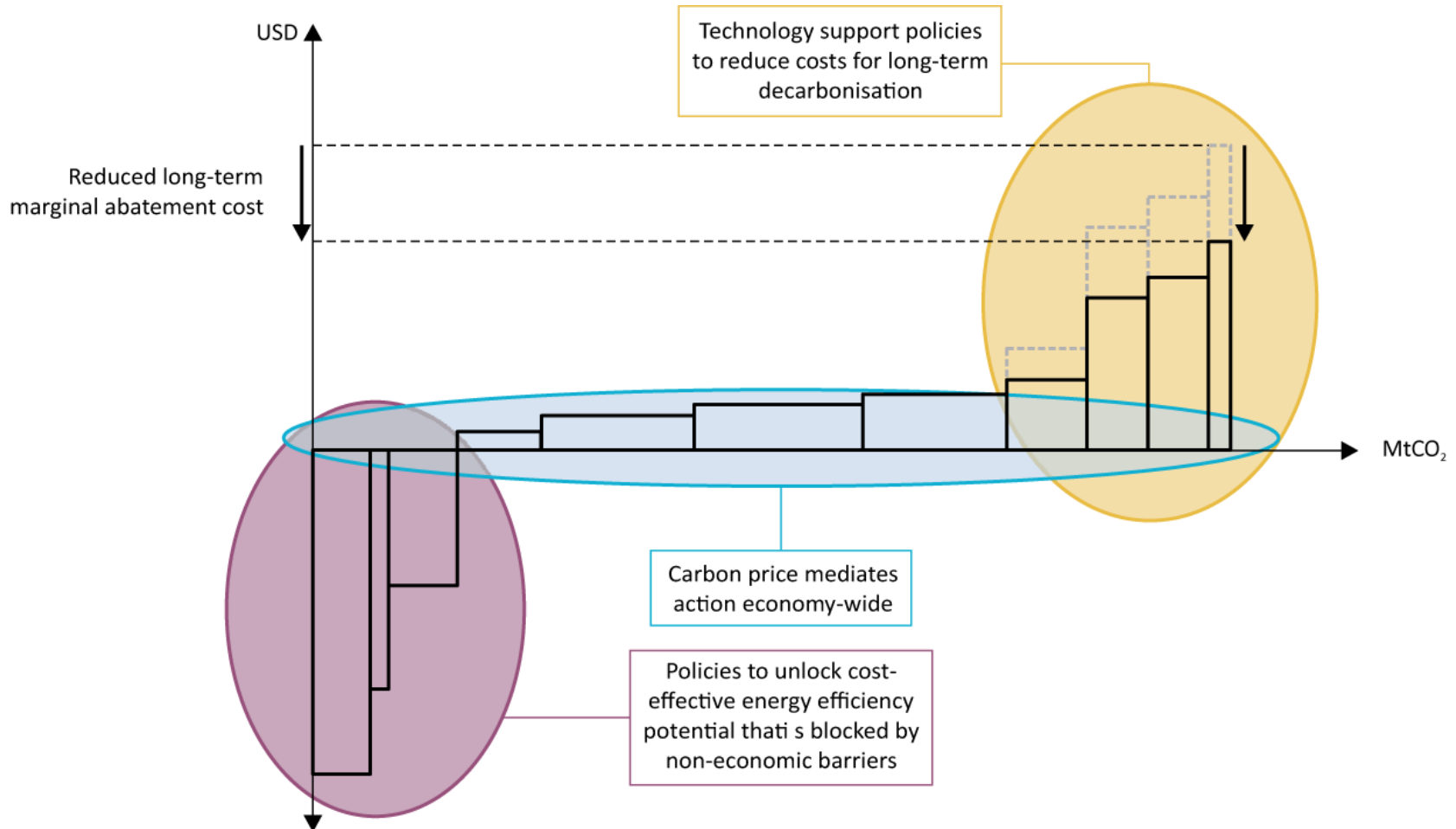


## Global cost curve for Greenhouse Gas Abatement

source: "A Cost Curve for Greenhouse Gas Reduction", The McKinsey Quarterly, 2007 No. 1



# The core policy mix



*Carbon price, energy efficiency policy and technology support are the backbone of a least-cost package to achieve 2DS.*



# Public Policy for Climate Change



# Main Message

- History of climate change policy debate suggests complex nature of global politics
- Science matters, but conflicts among nations and group of nations seem much more influential
- Not only conflicts between North and South, but conflicts among the North and the South are also important
- Innovative market oriented approaches, such as putting carbon price, are necessary



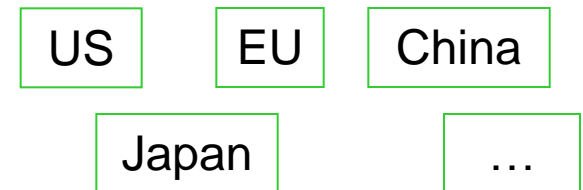
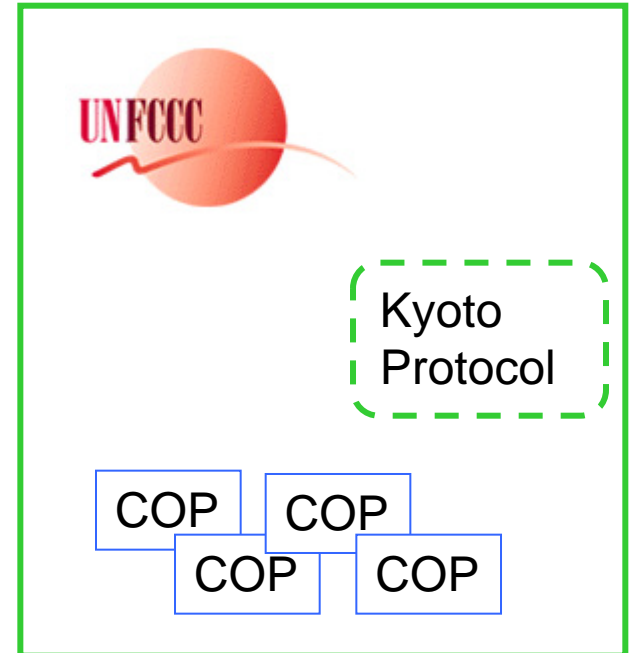
# History of Global Climate Change Policies

- **1972**: UN Conference on Human Environment (Stockholm Conference)
- **1987**: Brundtland Commission in its final report “Our Common Future” -- “Sustainable Development”
- **1988**: Toronto Conference on the Changing Atmosphere (Toronto Conference)- Origin of IPCC
- **1992**: UN Framework Convention on Climate Change (UNFCCC) at Rio Summit – Global Framework for Reduction of Greenhouse Gas Emissions
  - basic principle of *“common but differentiated responsibilities and respective capabilities”* agreed that all parties, including developing countries, take responsibility for implementing global warming measures at different levels.
  - A total of 189 countries, including the United States, participate in the convention.



# UNFCCC

- **United Nations Framework Convention on Climate Change (UNFCCC)** was one of three conventions adopted at the 1992 "Rio Earth Summit."
- **Conference of the Parties (COP)** is the prime authority of the Convention.
- Ultimate objective of stabilizing greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system."
- Kyoto Protocol is an agreement under the framework of UNFCCC.



# “Putting Carbon Price” can be the answer..

We therefore urge policy-makers to focus on introducing a clear carbon price framework in a stable and timely manner, namely:

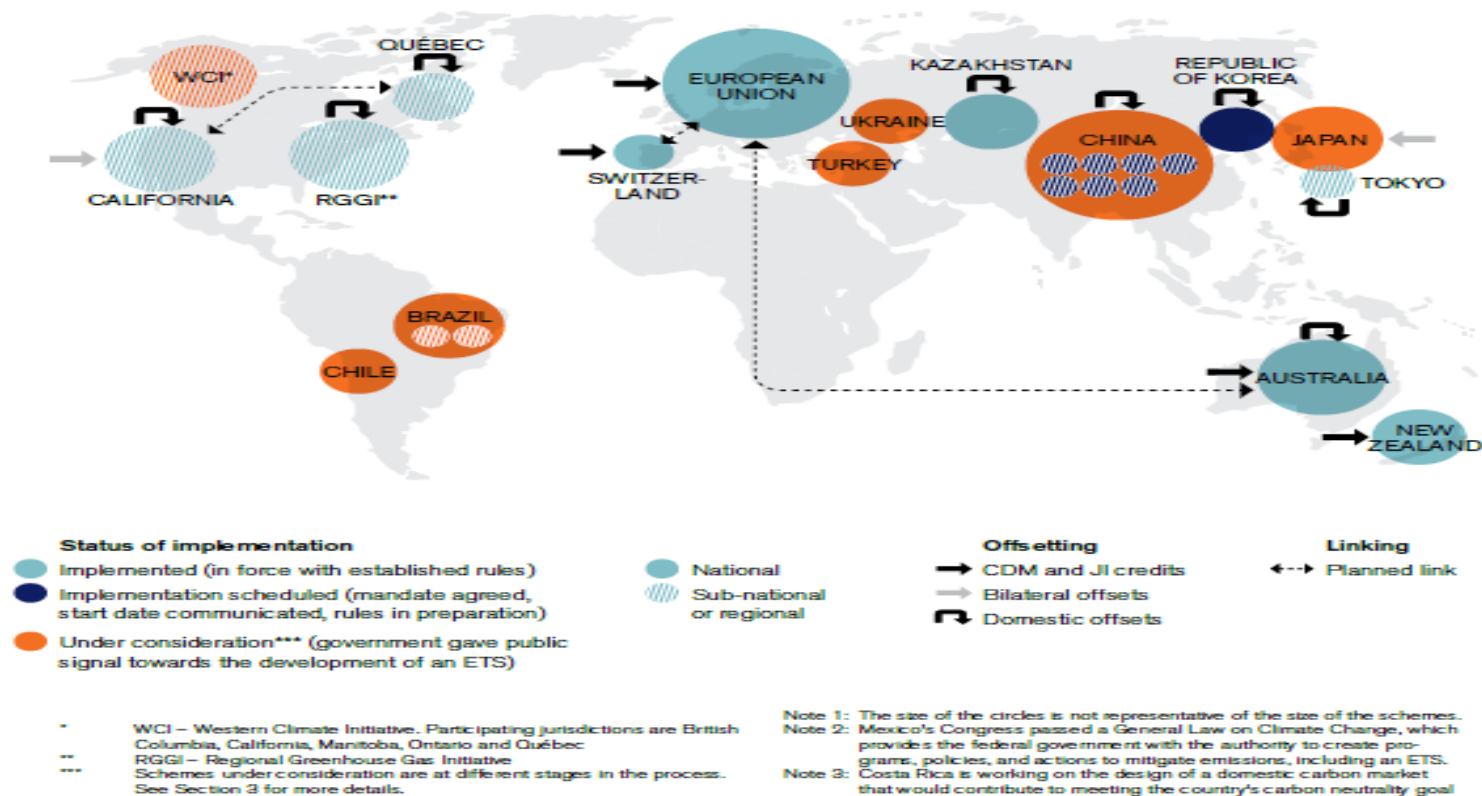
- Make carbon pricing a central part of national policy responses.
- Work towards the long term objective of a carbon price throughout the global economy.
- Set sufficient ambition through internationally agreed targets to drive change at a pace commensurate with the 2C goal.

Source: The Carbon Price Communique, May 2013,

<http://www.climatecommuniques.com/Carbon-Price-Communique.aspx>



**Figure 1:** Map of existing, emerging, and potential emissions trading schemes



*» Today, countries with carbon pricing mechanisms implemented and scheduled emit roughly 10 GtCO<sub>2</sub>e/y, equivalent to 21% of the 50 GtCO<sub>2</sub>e emitted globally. If China, Brazil, Chile, and the other emerging economies eyeing these mechanisms are included, carbon pricing mechanisms could reach countries emitting 24 GtCO<sub>2</sub>e per year, or almost half of the total global emissions.*



Source: The World Bank, Mapping Carbon Pricing Initiatives” Washington DC May 2013, [http://www-wds.worldbank.org/external/default/WDSP/IB/2013/05/23/000350881\\_20130523172114/Rendered/PDF/779550WP0Mappi0til050290130morning0.pdf](http://www-wds.worldbank.org/external/default/WDSP/IB/2013/05/23/000350881_20130523172114/Rendered/PDF/779550WP0Mappi0til050290130morning0.pdf)